IX. *Description of the Corundum Stone, and its Varieties, commonly known by the Names of Oriental Ruby, Sapphire,* &c.; *with Observations on some other mineral Substances. By the Count de* Bournon, *F. R. S.*

Read March 25, 1802.

WHEN, in the year 1798, I presented to the Royal Society, in conjunction with Mr. GREVILLE, a Paper on the Corundum Stone,* I gave some hints of an opinion which I, as well as Mr. GREVILLE, had already formed, namely, that the said stone was absolutely of the same nature with those stones or gems which mineralogists, following the example of the jewellers, had hitherto distinguished by the epithet *oriental.* This opinion was founded upon circumstances which appeared to me perfectly satisfactory; but these circumstances had not yet been sufficiently examined, nor were they sufficiently striking, to

* See Phil. Trans. for 1798. p. 428. My principal intention, in the Paper here referred to, was, to bring together the various observations which had been then made respecting the stone here treated of. The great number of specimens which have since been successively sent from different parts of the East Indies, have enabled me to form a more correct, and, in some respects, a different opinion of it. I therefore thought it would be of more advantage to science, instead of presenting to the Royal Society a supplement to my former Paper, to collect into one point of view, every information I could obtain upon the subject. I have consequently endeavoured, in the following Paper, to give, as far as I am able, a complete mineralogical history of this stone; my former account being, when compared with this, a very imperfect one.

obviate every possible objection; and, consequently, my opinion was not yet in a state fit to be presented to the Royal Society, as an established truth. Since that time, I have never lost sight of this object, nor have I neglected any means in my power, which could conduce to the end I had in view; and I may say, that my success has far surpassed my expectations. The specimens of corundum that have been lately sent from India, joined to the very considerable collection of oriental gems, in their perfect crystalline forms, which I have been able to procure, have afforded me the most satisfactory demonstration that a mineralogist can wish for; and nothing was now wanting to fix, in a complete and decisive manner, the general opinion respecting this stone, except to give it that additional support which is furnished by chemical investigation. Mr. KLAPROTH indeed had already published an analysis of the corundum stone, and of the sapphire; but he had not submitted to the same scrutiny, the perfect red corundum or oriental ruby; it is possible also, that the specimens of corundum he made use of in his analysis, which had been taken from among the first specimens of this stone sent from India, were not so pure as might have been wished, and that this impurity was the cause of the difference, (which however was very trifling,) between the result of their analysis and that of the sapphire. I therefore chose, from among the specimens of corundum which had been sent from China, from the kingdom of Ava, from the Carnatic, and from the coast of Malabar, such pieces as appeared to me the most pure; and, after having added to them a quantity of oriental rubies and sapphires, sufficient for many repeated analyses, I requested Mr. CHENEVIX, whose chemical labours are so useful to mineralogy, by his constant application

of them to that science, to have the kindness to join with me in the investigation I had undertaken. The Royal Society will perceive, in the detail given by Mr. CHENEVIX himself, of the analyses which he has made, not only of the different varieties of corundum, but also of the substances which accompany this stone in its matrix, how very satisfactory to science are the results of those analyses; insomuch, that I can now offer to the Society, as one of the best established truths, what, in the year 1798, I mentioned merely as a suspicion which had great probability in its favour; and can also, in consequence of the particular study I have made of all the varieties of stones that I have here joined together, under the general denomination of corundum, present to the Society a collection of facts, for the most part unknown, which, altogether, may be considered as forming a mineralogical history of this substance.

Although the epithet oriental has been for a long time used by the lapidaries, to express, in gems or precious stones, a degree of hardness superior to that of other stones, (the diamond excepted,) which made them capable of taking a more brilliant polish; and although, following the example of the lapidaries, naturalists had employed the same term by way of distinguishing them, there still remained a great uncertainty, respecting the nature of the analogy which really existed between the various stones to which the above epithet was applied.

The nomenclature here spoken of was not, at its origin, the result of any mineralogical knowledge; in consequence of which, a number of stones, of a totally different nature, were united together, for no other reason but because, among those of the same colour, some were found to be of a much superior

degree of hardness to others; and, as those which were the hardest most commonly came from the East Indies, all hard gems were called oriental, as a general mark of discrimination. The chief distinguishing character of gems was then derived from their colour, which had caused them to be denominated sapphire, ruby, amethyst, topaz, emerald, chrysolite, &c. and it was thought sufficient to add to these names the epithet oriental, to distinguish those among them whose hardness was superior to that of the others.

ROME' DE LISLE was the first mineralogist who threw a gleam of light, into the obscurity which existed in this confused assemblage of stones. His classification of gems, although it had not yet attained the degree of perfection to which the science of crystallography (of which he had just laid the foundation) may hereafter carry it, was undoubtedly one of the greatest steps mineralogy had made, at the time when the second edition of his work, upon this new character of stones, was published. After having fixed, according to their different characters, and particularly according to that which was derived from their crystalline forms, the place which each of the species composing this particular class of lithology ought to occupy, he placed at the head of them, under the title of *oriental ruby*, all those stones which, being possessed of a degree of hardness superior to that of all others, (except the diamond,) admitted a more brilliant polish, and appeared under the form of a hexaedral pyramid, or of two, joined base to base, the solid angle of whose summit, taken upon two of the opposite faces, varied, according to him, from 20° to 30°. He added also, that this stone presented all sorts of colours, either separately, or united together in the same stone. Nearly at the same time,

Mr. WERNER, following the system his genius had just then formed in mineralogy, was conducted to exactly the same results.

The very small number of perfectly defined crystals of this stone which existed in the cabinets of Europe, (they being much more rich in cut and polished specimens,) did not permit either of the above-mentioned mineralogists to obtain a clear idea of the whole of its characters, so as to enable him to give a proper description of it. ROMÉ DE LISLE, indeed, may be said to have made a step backwards, by excluding from the number of its crystalline forms, the rhomboid, which, in the first edition of his Crystallography, he had assigned to it, on account of a crystal of that form, which was among the stones preserved in the *Garde Meuble* of the King of France. This stone, which was of a blue colour inclining to purple, and of a very considerable size, (since it weighed no less than 132 carats,) had been polished; a circumstance which had necessarily altered its form in some measure, although there is reason to believe that it had been polished only upon its natural surfaces. ROMÉ DE LISLE, however, who had, merely for the above reason, excluded the rhomboid from the forms of the sapphire, being induced afterwards to recur to his former opinion, made another mistake, by assigning to this substance, the rhomboid of sulphate of iron or martial vitriol, (the measures of which are very nearly from 82° to 98°,) as that which properly belonged to it.

Our mineralogical knowledge with respect to corundum, was therefore very little advanced, when we became acquainted with that which was sent from India. Mr. GREVILLE, in the Paper to which I have already referred, has given a very interesting and instructive account, not only respecting the introduction of this

stone into Europe, but also respecting the information which, in consequence of his repeated inquiries, he had been able to obtain with regard to its local situation; and it is chiefly to him that we are indebted, for nearly all the specimens of this stone which exist in the various collections, as well as for the attention which has been paid to it.

From the moment when this stone became known, the opinions which were formed, respecting the place it ought to occupy in mineralogy, were very various; indeed, it was natural they should be so, with regard to a stone which, as yet, was only known by means of a few specimens, (by no means sufficiently numerous to supply every collection,) and whose local situation, as well as every thing else relating to it, was totally unknown. It has suffered, in this respect, the fate usually attendant on things so circumstanced; yet, whatever erroneous notions have hitherto been entertained respecting it, it has at last, I trust, found the place assigned to it by nature and truth.

The progress of chemistry, with respect to this stone, has not been more certain than that of mineralogy. It was first placed among those substances which were considered as composed of new earths; afterwards it was classed among those which were found by analysis to be chiefly, and indeed almost exclusively, composed of argill. This was already a great step towards the knowledge of its real nature; since it was thereby placed, if not by the side of, at least at a very inconsiderable distance from, the oriental gems, then known chiefly by the name of sapphire.

It is, in fact, among those gems or stones, now known by the names of sapphire, oriental ruby, &c. that corundum ought

to be placed; but the progress by which we have arrived at this degree of knowledge was necessarily very slow, and was impeded by continual obstacles: for the scarcity and smallness of the crystals of corundum, and the impression naturally made upon our minds by the various appearances it exhibited to us, were by no means likely to lead us to form a true judgment respecting it. So that Mr. WERNER, whose great and acknowledged talents have justly caused his opinion to be considered, nearly throughout all Germany, as of the highest importance in all mineralogical decisions, has hitherto continued to place corundum between pitchstone and felspar; consequently, he has removed it to a considerable distance from the sapphire, since there exists, according to his classification, nearly thirty intermediate substances.

Crystallography also offers some difficulties with respect to this stone; and these difficulties are only to be guarded against by a very particular study of it, and especially by an accurate examination of all its varieties, as objects of comparison. The Abbé HAUY, to whose great knowledge of crystallography all Europe is eager to do justice, although he gave some indications that he began to waver in his opinion, did not think there were reasons sufficiently strong to adopt that which I had, without satisfactory evidence, advanced in 1798; and has continued to separate the corundum from the sapphire, giving to the latter the name of *Telesie*. In the new System of Mineralogy, which the Abbé HAUY has just published, he places corundum immediately after felspar, and before ceylonite, the name of which he has changed into *Pleonaste*. One cannot help being astonished that the very great hardness of this stone, as well as its great gravity, did not lead him to

place it nearer those stones with which, from their possessing those two qualities, it seemed to have some analogy. Perhaps he was not in possession of specimens of sapphire, or of oriental ruby, or of corundum, sufficiently characterised to serve as objects of comparison; and I cannot help expressing great regret, that the crystals of corundum which were sent to him by Mr. GREVILLE, selected by myself from his superb collection, and to which I had the pleasure of adding an almost equal number from my own, were not sufficient to carry conviction to Mr. HAUY's mind; as it would have given me great satisfaction to find that my observations, upon this interesting substance, perfectly coincided with his. The opinion of a naturalist so justly celebrated as Mr. HAUY, will naturally have great weight in the minds of those who pursue the study of mineralogy; for which reason, after giving a particular description of corundum, comprehending all the characters which are peculiar to it, I shall endeavour to remove every objection which this mineralogist still thinks it right to offer, against its union with the sapphire, oriental ruby, &c.

The substance here treated of, has hitherto presented itself to our notice under two appearances, which differ so much from each other, in the greater number of those characters which most forcibly affect our senses, particularly those which concern the organ of sight, that we cannot be much surprised to find that mineralogists feel some reluctance, at the idea of uniting together substances which appear so very dissimilar.

Under one of these appearances, in which it is known by the name of corundum, this substance presents itself either in fragments, or in crystals of a pretty large size; sometimes, indeed, of a very considerable one. The surface of these crystals is

generally dull and rough; their texture, which is very much lamellated, is shown to be so by their fracture, which is obtained without much difficulty, as the adherence of their crystalline laminæ to each other is not very strong, and is easily overcome; and the crystal or fragment may always be brought to the rhomboid, its primitive form. Their colour, which is most commonly rather dull, is a whitish, greenish, and sometimes yellowish gray. Specimens of a purplish red, or of a blue colour, have always been extremely rare; indeed, a short time since, no such specimens were known, excepting a very few, preserved in the collection of Mr. GREVILLE, and some small fragments he had given away; but the specimens which have been lately sent from the district of Ellor, have contributed to increase their number.

Under the other appearance, (in which this substance is known by the names of sapphire, ruby, &c.) it offers itself, on the contrary, in crystals which are generally of a very small size, and have a smooth and brilliant surface. Their transparency is often very great; and it seldom happens that they are not semi-transparent, in a greater or less degree. They are more difficult to break in the direction of their crystalline laminæ; and this difficulty increases, in proportion to their purity and their brilliancy. Their colours are much more beautiful, more variegated, and more lively.

With respect to the name of this substance, as, in its most common state, it is known in India, (its native country,) by the name of corundum, and as that name has been generally adopted in Europe, I have thought proper to continue it, and shall distinguish, by the terms *perfect* and *imperfect*, the two different states in which it presents itself to our observation. Nothing,

in my opinion, occasions greater obstacles to the progress of a science, than making a change in its nomenclature, especially when that change is made without a general agreement. For, by this means there exists no fixed basis; and, consequently, every one thinks he has a right to exercise an arbitrary power in this respect, and to reject the name given to a substance by those who first observed and described it, for the purpose of giving it one more suitable to his own ideas. And thus, at last, it becomes necessary, (in order that the labours of our predecessors may not be wholly useless,) to fill the new works on the subject with a tedious list of synonyms, which too often becomes in the end a mass of uncertainty, and a subject of everlasting discussion.

COLOUR.

Although the colour of stones, strictly speaking, may be considered as a very variable circumstance, and as one which can by no means be included among those fixed characters which determine the nature of the stone, it is nevertheless certain, that many stones seem disposed to assume some colours in preference to others; and, therefore, the colour of a stone, though an uncertain character, may sometimes serve as a secondary mark of distinction; particularly, if we are cautious not to draw any inferences from it, except in conjunction with other characters. As its chief use is, to fix the value of precious stones, and as, in those here treated of, it has served as a basis for the former classification of them, it becomes more necessary to give a minute description of it in this substance than in any other.

I have already said, that the colour of common corundum,

(which I shall in future distinguish by the name of *imperfect* corundum,) has, in general, very little brilliancy; but, in proportion as the crystals announce, by their greater transparency, a greater degree of purity and perfection, their colour becomes more lively and more brilliant; this, however, seldom happens, except in crystals of a small size. The colour of these crystals is various, and seems to depend very much upon the place where they are found. In the Carnatic, the prevailing colour is a grayish white; which, however, very often approaches to a pale green, and sometimes to a yellowish cast. They are also found, but much more rarely, of a red, and of a blue colour; and, when they are of those colours, the red always inclines to the purple, and the blue is of that azure kind which is generally known by the name of sapphire blue. In the corundum of China, and in that of the kingdom of Ava, the colour is generally a green, more or less deep, with a dull appearance; or it is brown. The corundum of the coast of Malabar, appears of a reddish brown in those parts which are opaque; but, whenever there is, in any part of it, the smallest degree of transparency, the forementioned colour always appears to be accompanied by a tinge of purple.

In the perfect corundum, which is found in Pegu and in Ceylon, but which is now most commonly brought (when in its natural or unpolished state) from the last mentioned place, the colours are much more various, and more lively. The chief of these colours are, red, blue, and yellow. The red colour constitutes the stone known by the name of oriental ruby; but it seldom happens that this colour has not a small mixture of blue, which gives it a tinge slightly inclining to purple. The blue colour is always that which is known by the name of azure

blue; and the stone which possesses this colour is distinguished by the name of sapphire. The yellow colour is seldom pure, being in general more or less mixed with a reddish tint. The oriental gem of this colour is called the oriental topaz. From a duly proportioned mixture of the blue and the red, is produced the purple colour, which constitutes the oriental amethyst. Sometimes the red colour is predominant, at other times the blue; and, in the latter case, the stone possesses that beautiful purple colour which is so pleasing to the eye. Stones of this colour are among the most rare of those belonging to this substance. By the union of the blue colour with the yellow, is formed the green, which produces the oriental emerald; but there is usually mixed with this colour a small proportion of red, which gives to the green a brown and rather dull tinge. Sometimes however the yellow colour is predominant, which of course gives the green a yellowish cast, and then the stone becomes the oriental chrysolite. I have not yet seen any of the green stones, or oriental emeralds, in which the green colour was perfectly pure and brilliant, as it appears in the true emerald, called the peruvian one. In the mixtures of which I have just spoken, the colours are, in general, perfectly blended together; sometimes however they exist in a separate state, and so distinctly, in the same stone, that the mixed colour is only perceptible at the point where the different colours meet. At other times, these colours being only coarsely mixed, and not blended together, the stone presents the one or the other of them more distinctly, according to the position in which it is held.

TRANSPARENCY.

The crystals of corundum from the Carnatic, having their

surface always rough, and being usually more or less impregnated with fine particles of the various substances which compose their matrix, very seldom possess any degree of transparency; but, when these crystals are broken, their fragments generally have a degree of semi-transparency, but most commonly a very slight one, unless the fragments happen to be very thin; even then, I have never found them perfectly transparent.

If such of these fragments as have the greatest degree of semi-transparency, are held between the eye and the light, there may be observed, within their substance, a great number of lines or fissures, which cross each other, and prevent the free passage of the light, the greater part of which is reflected. These fissures, which arise from there not being a complete adherence between all the parts of the crystalline laminæ, are the principal cause of the slight degree of transparency commonly met with in the kind of corundum here spoken of; which kind may truly be said not to have attained, in its crystallization, all the perfection it is capable of acquiring, and which may be observed in the perfect corundum of Ceylon.

I think it also right to observe, that the corundum of the Carnatic, when of a red or a blue colour, has always a greater degree of transparency, and is more pure, than that which is of any other colour; and, in these respects, the corundum of a blue colour is much superior to that which is red.

In the imperfect corundum of China and of Malabar, although the surface of the crystals is also generally rough, yet, as they are less impregnated with foreign substances, it is not uncommon to observe in them a greater or less degree of transparency at their edges. Some crystals have, indeed, been sent to us from China, (very small ones, I confess, but very perfect,) which

possessed a degree of transparency very little inferior to that of the perfect corundum of Ceylon. The terminal faces of the crystals from the two last mentioned places, are very frequently what is called *chatoyant;* a property of which I shall hereafter speak more particularly.

The perfect corundum of Ceylon, whatever may be its colour, always has a greater or less degree of semi-transparency; and very often is perfectly transparent. Sometimes, indeed, the crossed fissures already spoken of, as existing in the imperfect corundum, are also to be observed in the interior part of this; but, when that is the case, they are less strong, and less numerous. The crystals of the perfect corundum have a smooth and brilliant surface; and they show all the transparency their substance possesses, without its being necessary, as in the imperfect corundum, to break them for that purpose. In general, when they have an inferior degree of transparency, whatever their colour may be, their terminal surfaces possess the appearance called *chatoyant,* which, as I have already said, is very frequently observed in the corundum of China, and in that of the coast of Malabar.

In general, although the perfect corundum of a blue colour, or sapphire, has exactly the same characters as that which is of a different colour, it appears to me certain, if I may judge from the great number of specimens I have seen, that it more commonly possesses a perfect transparency, than that which is of any other colour. I have already made a similar observation, in speaking of the imperfect corundum of the Carnatic. To this circumstance must be attributed, the superior value of an oriental ruby, if without defect and of a certain size, when compared with that of a sapphire of equal size and equally

perfect. To the same cause must also be ascribed, the scarcity of fragments of sapphires, in comparison with those of rubies, in the sand of Ceylon which has passed through the hands of the lapidaries; the fragments of the former being usually more transparent, they are selected from it, as more worthy to be cut and polished.

HARDNESS.

Corundum is, next to the diamond, the hardest of all stones; but, with respect to this character, the degrees of intensity are various; and this variety depends principally upon the degree of purity, and the colour, of the stone.

When the imperfect corundum of the Carnatic is neither of a blue nor of a red colour, its hardness is less considerable, in proportion as its transparency is less, and its internal substance more full of those lines or fissures, which, as I have already said, are commonly observed in it. Such corundum may be scratched by that which is more transparent, though of the same colour. The latter, (supposing the degree of purity to be nearly equal,) may in its turn be scratched by that which is of a purplish red; and this last, by the corundum of a blue colour; which is the hardest of all those varieties of this stone that I have distinguished by the name of imperfect corundum. The hardness of the imperfect corundum of China, and of that from the coast of Malabar, appear to be equal. This hardness, which is rather inferior to that of the blue corundum of the Carnatic, is however somewhat greater than that of the other varieties.

The perfect corundum of Ceylon of a red colour, or oriental ruby, the hardness of which seems to be nearly the same as that of the imperfect blue corundum, is superior in hardness

to all the other varieties of the latter kind. In the perfect corundum of other colours, the hardness is nearly the same as in the red; that which is of a blue colour, or sapphire, and only that, rather exceeds the others in hardness. We have just seen, that in the imperfect corundum also, the blue colour was accompanied by a degree of hardness greater than that of the other colours.

This substance emits pretty bright sparks, when struck with a piece of steel; but they are by no means proportioned to its hardness. If a piece of flint be struck with the same force, the sparks it produces are more numerous, as well as more bright; and it is possible to obtain sparks from flint, by a very slight blow, such as would not be sufficient to produce them from perfect corundum. It is also necessary, in order to obtain sparks from corundum, that the stone should have pretty sharp edges: if the part that is struck is obtuse, it is with some difficulty that any sparks can be obtained. The imperfect corundum, however, has, in this respect, some advantage over the perfect kind.

PHOSPHORESCENCE.

The substance here treated of becomes, like quartz, phosphorescent by collision; it requires only, in order to exhibit this property, a somewhat stronger degree of friction. The light which it emits has also less intensity; and does not appear to be accompanied by the smell which is peculiar to that obtained from quartz. A very remarkable circumstance may likewise be observed respecting this light. In all the varieties of this stone which are of a red colour, whether of the imperfect or of the perfect kind, or oriental ruby, the light here spoken of is of a very deep fire colour, similar to that of red hot iron, when

heated to the degree known by the term *cherry red.* The sparks which are obtained from this stone by means of a piece of steel, have also some appearance of the above colour. These phenomena may perhaps serve to assist us in acquiring further knowledge respecting the cause of the phosphorescence of stones, of which we have hitherto had no very satisfactory explanation.

GRAVITY.

The specific gravity of corundum, in its different varieties, presents a series of interesting facts, particularly when they are compared with what has been already observed with respect to its different degrees of hardness. The great interest I have felt in the study of this substance, has caused me to take particular care in the examination of such of its properties as might lead to a perfect knowledge of it. I will now state the results of the observations with which the character now treated of has furnished me.

Of 33 specimens of the different varieties of imperfect corundum, the mean specific gravity was 3931. The lightest was 3875; and the heaviest 3981. Six of the 33 were above 3900. Eleven were between 3900 and 3931; and the remaining sixteen were above 3931, which, as I have already stated, was the mean proportion.

The mean specific gravity of the perfect red corundum, as determined by 20 specimens of oriental ruby, was 3977. The lightest of these was 3933. Five of the specimens were above 4000. One alone was as high as 4087; it was of a deep red colour, was perfectly transparent, and had been cut.

Sixteen different specimens of sapphire, gave a mean specific gravity of 4016. The lightest was 3907; it had scarcely any

colour, and was nearly opaque. The heaviest was as high as 4161; this was of a beautiful deep blue colour, and was very transparent. Three of the 16 were above 4100.

The inferences which I think myself warranted to draw from the results of the above-mentioned trials, are,

1. That the specific gravity of the imperfect corundum is always less considerable than that of the perfect kind.

2. That this gravity varies according to the degree of perfection of the crystallization; and, consequently, according as the stone is more or less transparent.

3. That, in general, the corundum of a blue colour, whether of the perfect or the imperfect kind, is of a greater specific gravity than that of any other colour.

What is here stated respecting the specific gravity of the different kinds of corundum, is exactly analogous to what has been already mentioned respecting their various degrees of hardness.

CRYSTALLINE FORMS.

The primitive form of corundum, whatever may be its degree of perfection, is a rhomboid slightly acute; the obtuse angles of the planes measuring 94°, and the acute ones 86°. (See Plate VI. Fig. 1.) The description of the crystalline forms will be more easily and more clearly understood, by considering (as I shall constantly do in what follows) this rhomboid as being formed by the union of two triedral pyramids, united at their bases; the solid angle of the summit will then be formed by the meeting of three of the more acute angles; and its measure, taken upon one of its edges, and in the middle of the opposite face, will be very nearly 95° 30′.

Whatever the form of the crystals of this substance are, they may always, by dividing them, be ultimately brought to the rhomboid here spoken of; and, when they are broken, such of the fragments as are made in the direction of the laminæ, very often present the same rhomboid, in a very regular form. Indeed, it is the only method of obtaining this crystal, in the imperfect corundum; for, among all the crystals of that kind of corundum which have been sent from the East Indies, not one has yet presented its primitive form. With respect to the perfect corundum, I have been more fortunate; as, besides several fragments which exhibited this rhomboid very exactly, I have found four of these primitive crystals perfectly defined. One of them is a sapphire, and is in the collection of Sir JOHN ST. AUBYN; the three others are oriental rubies, and are in the collection of Mr. GREVILLE.

First Modification. The summit of the pyramid, (as very frequently happens in calcareous spar, and in most of the stones which have a rhomboid for their primitive form,) is often replaced by a plane which is perpendicular to the axis. This plane then makes, with those of the rhomboid, an angle which differs very little from 122° 30′; and, as the extent of the plane is more or less considerable, it often causes great difference in the appearance of the crystals. Sometimes it does not descend so low upon the faces of the rhomboid, as to reach their small diagonal. (Fig. 2.) At other times, it exactly reaches to the diagonal. (Fig. 3.) And, very often, it descends more or less below it. (Fig. 4). This last variety is frequently met with in the perfect red corundum, or oriental ruby. I also know four instances of this form in the sapphire. The variety shown in Fig. 3 is rather scarce; but that of Fig. 2 is the most rare of the

whole. I have likewise observed the two last, among some small crystals of imperfect corundum from China, which were pretty transparent.

Second Modification. At other times, the edges of the base of the primitive rhomboid are each of them replaced by a single plane, which is parallel to the axis, and which, when its extent is rather considerable, separates the two pyramids by a hexaedral prism with rhombic planes. I have never seen this modification with complete pyramids, as it is represented in Fig. 5, but I have often observed it combined with the preceding modification. This combination is not unfrequently met with in the oriental ruby, in which, the two varieties represented in Figs. 3 and 4 are found with a small beginning of a prism, as is shewn in Figs. 6 and 7. There are also in the collection of Sir JOHN ST. AUBYN, two crystals of sapphire, belonging to the same variety, one of which is tolerably regular in its form; but it is much more common to find these crystals with prisms of rather greater length, as is represented in Figs. 8 and 9. In Mr. GREVILLE'S collection also, there is contained a crystal of a pretty large size, and very perfect, in which the plane that has replaced the solid angle of the summit of the pyramid is very small, as in Fig. 10. All these varieties, but particularly those represented in Figs. 8 and 9, are likewise found among the small transparent crystals of imperfect corundum brought from China.

When the decrease produced by the plane which has replaced the solid angle of the summit of the rhomboid, has begun to take place nearly at the same time with, or even previous to, that which gives rise to the planes which replace the edges of the base, (as is indicated by the length of the sides of the

prism,) it often happens that there remains no trace of the planes of the primitive rhomboid: the crystal is then a regular hexaedral prism. (Fig. 11.) This variety, which is very common in the perfect corundum of a red or of a blue colour, is also common in the imperfect kind; it is indeed, in certain districts, particularly in the Carnatic, almost the only form that is met with. In all these crystals, the prism here spoken of differs considerably in its length; sometimes it is very much elongated; at other times it is very short, as is represented in Fig. 12.

Third Modification. The primitive rhomboid is frequently observed to have undergone, in its crystalline laminæ, a decrease at those flat angles which rest upon the common base. This decrease occasions, in each of the pyramids of the rhomboid, six new planes equally inclined, which thereby render the pyramids enneaedral, (as is seen in Fig. 20,) and which, when this modification is perfect, (that is to say, when the planes belonging to it have destroyed every trace of the primitive rhomboid,) change the crystal into a dodecaedron, formed by the union, base to base, of two hexaedral pyramids with isosceles triangular faces, as in Fig. 13. At present, I shall only take notice of the pyramidal form of these crystals, without paying any attention to the inclination of the faces of the pyramids; for we shall see, at the end of this modification, that the decrease which occasions it is subject to considerable variation, changing, at the same time, the inclination the faces of the pyramids have to each other.

It very rarely happens that we find this dodecaedron perfectly complete, that is to say, with each of its pyramids terminating in a single point, by the exact meeting of all its faces. I know only

one instance of this form, which I met with in a small sapphire, that I have placed in the collection of Mr. GREVILLE. There are indeed two specimens, nearly similar to the above, in the collection of Sir JOHN ST. AUBYN; but two of the opposite faces of their pyramids have increased to a greater degree than the others, which renders them cuneiform.

It is much more common to find the crystals of this modification combined with the first, and consequently having the solid angle of their summits replaced by a plane. Sometimes this new plane is very small, as is shown in Fig. 14. At other times, it is more considerable, as in Fig. 15. The above varieties are less common in the red perfect corundum, or oriental ruby, than in the blue perfect corundum, or sapphire, of which it is the most usual crystalline form, and in which, the plane that has replaced the summits of the pyramids is frequently very small. These varieties are likewise often found among the crystals of imperfect corundum of China; but it is very rare, on account of the irregularity of their surface, to meet with them perfectly defined. They are met with in a much more perfect state, among the crystals from the coast of Malabar; some of these indeed are so perfect, that, were it not for their reddish colour, they would certainly be taken for very beautiful sapphires. One of these crystals, which is in Mr. GREVILLE'S collection, is more than an inch in length. Another, which is cuneiform, and has one of its pyramids broken, is above two inches long. In the crystals of imperfect corundum from the Carnatic, I have never met with any thing more than very slight traces or elements of this pyramidal form.

There frequently remain upon the crystals belonging to these varieties, particularly when the terminal faces are of a pretty

considerable size, more or less evident traces of the planes of the primitive rhomboid; as appears by small isosceles triangular planes, of greater or less extent, situated upon three of the alternate solid angles, formed by the meeting of the terminal faces with those of the pyramid. (Fig. 16.)

It very often happens, in this modification, that the plane which has replaced the solid angle of the summit, acquires a more considerable increase in one of the pyramids than in the other; and indeed, most commonly, this increase is such as to cause the pyramid entirely to disappear. The crystal then becomes a simple hexaedral pyramid, which is either complete, as in Fig. 17, Plate VII. (but this very rarely happens,) or has its summit more or less replaced. (Fig. 18, A.) This variety, which is very common in the crystals of perfect corundum, is also frequently met with in those of the imperfect corundum from China; and it is very usual to see, upon the solid angles of its terminal faces, small isosceles triangles, which are occasioned by the preservation of some parts of the planes of the primitive rhomboid; (Fig. 19.) but they are seldom so regular in their form as they are represented in the figure.

I have often seen small crystals of oriental ruby that exhibited a very pretty variety, as they showed, at the same time, the primitive rhomboid with its summit strongly replaced, and the incipient change to the form of the hexaedral pyramid which constitutes this third modification: this variety is represented in Fig. 20. There are, in Mr. GREVILLE's collection, two very perfect crystals of this form.

The second modification, that in which the pyramids of the primitive rhomboid are separated by an intermediate hexaedral prism, is often combined with the abovementioned union of

the first and third modifications. There exists, for example, in Mr. GREVILLE'S collection, an oriental ruby, which exhibits the variety shown in Fig. 20, with the rudiments of an intermediate prism, as is seen in Fig. 21. This variety is also sometimes found among the small transparent crystals of imperfect corundum from China.

In four other crystals, also in Mr. GREVILLE'S collection, the prism is very much elongated; and the plane which has replaced the solid angle of the summit of the pyramid is much more extended, as in Fig. 22. These crystals, which are oriental rubies, are in perfect preservation at their two extremities.

There is besides, in the same collection, another crystal, also an oriental ruby, which differs from the preceding, in having no traces left of the planes of the primitive rhomboid. The crystal, consequently, appears to be a regular hexaedral prism, with the edges of its terminal faces bevelled. (Fig. 23.)

In five others, the pyramid has made more progress; and, in all of them are to be seen, on their terminal faces, some slight traces of the primitive rhomboid. (Fig. 24.)

Lastly, in one other specimen, the pyramid is nearly complete, as in Fig. 25. I also know two sapphires, which exhibit an intermediate variety, between the two last-mentioned forms.

One of the most striking characters of corundum is, the great variety exhibited by this pyramidal modification, in the inclination of the faces of the pyramids to the axis of the crystal, and, consequently, in the more or less rapid decrease that has taken place in the crystalline laminæ, at the plane angles situated on the common base of the two pyramids which compose the primitive rhomboid. Among the crystals of imperfect corundum, from the different districts in which this substance

has been hitherto found, which form part of Mr. GREVILLE's collection, and are sufficiently perfect to admit of being measured with accuracy, there is one, of which the solid angle at the summit, taken in the middle of two of the opposite pyramidal faces, is 50°; two of 40°; two of 35°; nine of 24°; and seven of 12°. Among the pyramidal crystals of oriental ruby are, one of 50°; one of 40°; four of 30°; one of 24°; and four of 12°. In the sapphire there are, one of 50°; two of 40°; one of 35°; two of 30°; one of 24°; and two of 12°. If to these measures we add those of two sapphires, and of two oriental rubies, in the collection of Sir JOHN ST. AUBYN, we shall also have 58° and 20°; and we may consequently state, from our present knowledge respecting this substance, that it admits no less than eight different decrements of the laminæ, at the same angle of the base; each of which produces a pyramidal modification. And the measure of the solid angle of their summits, (considering the pyramids as complete, and supposing at the same time that the very great care I have taken has prevented me from committing any error,) are 58°, 50°, 40°, 35°, 30°, 24°, 20°, and 12°.*

This difference in the inclination of the faces of the pyramids, in the corundum of a pyramidal form, often appears in a very striking manner in the same crystal. I have frequently met with oriental rubies, and also with sapphires, in which the faces of the pyramids, after having for some time preserved a certain degree of inclination, evidently appeared to have changed it, in

* In Figs. 18 A, 18 B, and 18 C, are represented this simple pyramidal modification, having 58°, 35°, and 12°, for the measures of the solid angle of the summit of the pyramid: from these figures, it will be easy to form an idea of the appearance of those crystals which have the other measures above enumerated.

order to assume another; this change caused the crystal to terminate by a pyramid less sharp; and, in many instances, it was evident that it had happened several times successively. These variations do not always take place in a regular order in the same crystal; for it very often happens, that some of the faces have undergone two, three, or even four changes of inclination, while others have not undergone so many; and sometimes, indeed, have not undergone any at all. I have seen some of these crystals, of which the irregularity was such that, upon some of the faces, the degree of inclination was changed from a greater to a less; a circumstance which necessarily formed a depressed angle, and thereby produced a very irregular and even deformed shape, in the crystal itself. Among the very small number of crystals from the Carnatic which shew any disposition to assume the pyramidal form, I particularly observed one, in which this irregularity in the mode of decrease is very remarkable. This crystal, on three of its adjacent sides, appears to be a regular hexaedral prism; but, from nearly the middle of two others, also adjacent, it becomes pyramidal, and of that modification in which the solid angle of the summit is of 50°; and, from about one-third of the remaining side, it also assumes a pyramidal inclination, but of that modification in which the solid angle of the summit is of 40°. This crystal, which is represented in Fig. 26, is preserved in Mr. GREVILLE'S collection. These pyramidal modifications also very frequently demonstrate, by the great number of transverse striæ which are on their faces, and which sometimes resemble the steps of a staircase, the irregularity with which their decrements have taken place.

Fourth Modification. The primitive rhomboid sometimes undergoes, in those acute angles which contribute to the formation

of the solid angle of the summit, a decrease much more rapid than that we have already mentioned, when speaking of the first modification. This decrease replaces the solid angle by three new planes; which planes, if they were to become of such extent as to cause the primitive faces of the rhomboid to disappear, would occasion a secondary obtuse rhomboid, that would have considerable analogy, in the measure of its angles, with that rhomboid of calcareous spar which is called *lenticular;* that is to say, the solid angle of its summit would measure about 139°; and the plane angles of its rhombs 114° and 66°. I have not yet met with this rhomboid perfectly formed; but it exists, or at least one of its halves, in a very well defined state, at the summit of a simple pyramid, eight or nine lines in height, the solid angle of which summit measures 12°; it is represented in Fig. 27. The great number of striæ, parallel to the small diagonals of the primitive rhombic planes, with which the faces of the secondary rhomboid are covered, prevent me from being perfectly certain respecting the accuracy of the measures I have just stated; but, if they are not strictly exact, they must at least be very nearly so. The crystal I have just described is from the coast of Malabar, and is in Mr. GREVILLE's collection. The planes of the secondary rhomboid are slightly *chatoyant.*

Fifth Modification. Another mode of decrease, of a similar kind, but still more rapid, sometimes takes place at the same solid angle of the summit of the primitive rhomboid. The triedral pyramid which replaces this angle, is then much less elevated than in the preceding modification. When it is complete, that is to say, when there remains no trace of the planes of the primitive rhomboid, the crystal becomes changed into a

new rhomboid, which is much more obtuse than the former one. (Fig. 28.) The rhombic planes have 117°, for the measure of their obtuse angles; and 63°, for the measure of their acute ones. The solid angle of the summit of the pyramid is very nearly 150° 30′; consequently, the angle formed by the meeting of the bases is about 29° 30′.*

There are, in Mr. GREVILLE'S collection, two oriental rubies which exhibit this rhomboid completely formed; its planes are deeply striated, in the direction of the decrease; a circumstance which is very common in all planes that are the result of a rapid decrease, or in which the edges of the laminæ last deposited, deviate considerably from the edges of those which were already formed.

There are also, in the same collection, two perfect hexaedral prisms of corundum from the Carnatic, in which this modification shows itself by small isosceles triangular planes, situated upon three of the alternate solid angles of each extremity. (Fig. 29.) These planes may easily be distinguished

* After having, in this substance, met with a secondary rhomboid that exactly agrees with one of those belonging to calcareous spar, (although the planes which produce it are differently situated upon the primitive crystal,) it appeared to me very extraordinary to meet with a second, which had exactly the same proportions as another of the obtuse rhomboids of the abovementioned substance. In fact, there exists in calcareous spar, a rhomboid much more obtuse than that which ROMÉ DE LISLE named *lenticular*, (called *equiaxe* by the Abbé HAUY,) of which the measures are exactly the same as those which have just been assigned to the rhomboid of corundum; but there is the following difference between them, viz. in calcareous spar, this rhomboid is the result of a decrease along the edges of the pyramid belonging to the primitive rhomboid; whereas, in corundum, it is the result of a decrease at the angles which contribute to the formation of the solid angle of the summit. This modification of calcareous spar has not yet been described; but, indeed, the same thing may be said of many other modifications of that substance.

from those belonging to the primitive rhomboid: first, by their inclination, which is very different, as they make, at their meeting with the edges of the prism, an angle of 110°, whereas the others make an angle of 147° 30′. Secondly, they are usually very deeply striated; a circumstance which rarely occurs in the others. Of the two crystals I have just described, one is nine lines in diameter, and six lines in height; it is also slightly transparent at the edges. The other is much smaller, more transparent, and of a purplish red colour, but rather pale. It is one of the purest specimens of imperfect corundum, particularly of that from the Carnatic, I have ever seen.

There are frequently observed, in the small prisms of imperfect corundum, some traces of the planes above described; they may in general be easily known by their striæ. I have also seen crystals in which were united, at the same time, traces of the two secondary rhomboids of the fourth and fifth modifications, in the manner represented in Fig. 30.

Sixth Modification. There also appears to exist, in this substance, a third rhomboid, which is much more obtuse than either of the two preceding ones; at least it is only to such a modification that I can refer several crystals, both prismatic and pyramidal, of imperfect corundum, which made part of a parcel lately sent to Mr. GREVILLE, from the district of Ellore, in the northern part of the government of Madras. Among these crystals are many hexaedral prisms, of a perfectly regular form, which have their terminal faces inclined in a contrary direction, so as always to make, upon the edges of the prism on which they incline, angles of 100° and 80°. (Fig. 31. Plate VIII.) These terminal faces appear to me to belong to a very obtuse rhomboid, of which, the acute angles of the rhombic planes would

be 60° 46′; the obtuse ones 119° 14′; and the solid angle of the summit 165°. The crystal I have just described, would then be nothing more than the prismatic modification, combined with that which occasions this rhomboid; at both extremities of which, one of the faces of each of the obtuse triedral pyramids, belonging to the new rhomboid, would have acquired (in a contrary direction with respect to its extremities) such an increase as would cause the other faces to disappear. These two faces, having now become the terminal ones of the hexaedral prism, would in fact make, with those edges of the prism on which they would incline, angles of 100° and 80°. This very obtuse rhomboid would be the result of a decrease analogous to the two preceding ones, but still more rapid. Many pyramidal crystals of this kind of corundum, present such inclined terminal faces; but with a difference, in the measure of their angles, conformable to the inclination of the edges of the pyramids.

Seventh Modification. The primitive rhomboid of this substance also undergoes sometimes, though very rarely, a decrease at those acute angles which rest upon the base; and this decrease is such, that it replaces each of the solid angles of this same base, by a plane which is parallel to the axis of the rhomboid. If this modification were complete, it would give rise to a regular hexaedral prism, which would differ from the prism of the second modification, in having its sides corresponding with the solid angles of the base of the rhomboid; whereas the sides of the other correspond with the edges of the said base. I know this modification only by a single crystal, which is in the collection of Mr. GREVILLE; in it is combined the modification here spoken of with the three first. This crystal, which is

of perfect red corundum, or oriental ruby, is almost exactly similar to that represented in Fig. 22, and indeed only differs from it by the prism being dodecaedral, as in Fig. 32.

Eighth Modification. I am also acquainted with this modification only by a single crystal. This crystal, which is a sapphire of a beautiful deep blue colour, is likewise in Mr. GREVILLE's collection. Its form is a simple hexaedral pyramid, which is almost complete, and has 24° for the measure of the solid angle of its summit. Each of its six edges are replaced by a very narrow plane, which is equally inclined upon the two faces that are adjacent to it. This renders the pyramid dodecaedral, with broad and narrow faces alternately, as in Fig. 33. Three of these new planes appear to me to be occasioned by a decrease, which has taken place at the obtuse plane angles that rest upon the base of the rhomboid, but which differs from those which occasion pyramidal modifications, and is of such a nature that (the new planes to which it gives rise being in pairs, and on the same level,) each of the solid angles of the base is replaced only by a single plane. The three others appear to me to be caused by a decrease at the acute plane angles that rest upon the base; but this decrease differs from that of the seventh modification, in being more rapid, and in having the planes to which it gives rise inclined upon the axis of the crystal. The three latter planes have the following peculiarity, viz. their inclination is exactly equal to that of the three others; so that, if the two modifications which are united together in this crystal were complete and separate, they would produce two acute rhomboids, perfectly similar to each other.

FRACTURE AND TEXTURE.

I have already observed, that all the stones which compose the various kinds of this substance, to which I have given the general name of corundum, have a lamellated texture, in a direction parallel to the faces of a rhomboid of 96° and 84°; and also, that they break in a direction parallel to the said faces.

The blue variety of perfect corundum, or sapphire, follows the above law, as well as all the other varieties. It is true, however, as I have already had occasion to mention, that the ease with which the crystals of this substance may be divided, is very various; but observation shows, at the same time, that these variations are governed, in the first place, by the degree of force existing in the attraction of the molecules which compose the crystals, as well as by the perfect adhesion of the crystalline laminæ (composed of these molecules) at all points of their surface; two facts, the existence of which is shown by the difference in the degrees of hardness and transparency of this stone, and which appears to be very considerable. In the second place, the variations here spoken of seem also to depend very much upon the colour these stones possess; for, as I have already observed, they must be governed by the force of attraction, which, in my opinion, varies with the colour. This force appears to exist in the highest degree, in the perfect corundum of a blue colour, or sapphire; it being with great difficulty that this kind of corundum can be broken, in the direction of its laminæ, in such a manner that its fracture shall present that even surface, and that kind of gloss, which fractures made in the above direction generally exhibit. It may be broken with equal ease in any other direction; for instance, in a direction

perpendicular to the axis of the crystal; but, in this last case, the fractures by no means possess such characters as might cause them to be taken for fractures made in the direction of the laminæ; they are always unequal, and partially conchoid. I will even confess, that I have not yet succeeded in breaking a sapphire, according to the direction of its laminæ, in a satisfactory manner. But that which art is not able to perform, is executed by nature: for, besides such sapphires as, upon their terminal faces, retain complete traces of the planes of the primitive rhomboid, I have frequently met with sapphires, both of the prismatic modification and the pyramidal one, in which there were, upon the said faces, one or more fractures, made exactly in the direction of the laminæ; and it was necessary to examine them with great attention, in order not to mistake them for true planes, representing those of the primitive rhomboid.* This kind of fracture is obtained with greater ease in the perfect red corundum, or oriental ruby; and still more easily, in the imperfect corundum. The latter presents, in this respect, a less degree of resistance, in proportion as it is less transparent, and has less colour. This character, however, is subject to great variation: there exist some specimens of this stone, in which such fractures as are here described may be made almost as easily as in calcareous spar; whereas, in others, they are obtained with much more difficulty. I have even seen some pieces which

* I have placed several of these crystals in Mr. GREVILLE'S collection, and also in that of Sir JOHN ST. AUBYN, and in that of Sir ABRAHAM HUME. The owners of these collections have confided to me the care and arrangement of them, with a degree of liberality which gives me every advantage that could be derived from the absolute possession of them, and consequently diminishes my regret for the loss of my own. I feel too sensibly these advantages, and many others resulting from their friendship and society, not to embrace with pleasure this opportunity of testifying my gratitude.

might be broken, with almost as much ease, in a direction contrary to that of the laminæ, as in the direction of the laminæ; but it most frequently happens, in this case, that the fracture, although made in the natural direction, has not the evenness such fractures usually have, but presents some irregularities, and likewise some conchoidal parts: this remark, however, applies only to such pieces as approach nearly to perfection, with respect to transparency.

There may frequently be observed, in these stones, a character which serves to confirm what I have said respecting the imperfection sometimes observed in their crystallization, which appears to me to arise principally from a want of absolute contact between all the parts of their crystalline laminæ. When some of the faces of the crystals correspond to those of the primitive rhomboid, whether these faces are natural ones or are produced by fracture, the edges of the crystalline laminæ are shown upon them, and sometimes very plainly, by lines which cross each other, in such a manner as to form rhombs of 96° and 84°. This character even becomes of great use in this substance, as it serves to distinguish, in fragments, (which are generally of hexaedral prisms, that being the most common form,) those faces which are occasioned by fracture, from those which correspond to the terminal faces of the prism. These last, also, frequently exhibit lines, which are likewise caused by the edges of the crystalline laminæ; but, as they extend to three only of the alternate angles of the terminal hexagonal face, they trace on it, by crossing each other, either equilateral triangles, or rhombs of 60° and 120°. Figs. 34, A, and 34, B, represent these two different appearances; the first upon the planes of the rhomboid; the second upon the terminal faces.

As it is by no means uncommon, in corundum, (in the same manner as is observed in the beryl,) to meet with elongated prisms, formed merely by the connection or contact of several prisms at their terminal faces, it frequently happens that these prisms, after being separated from each other, exhibit, upon the terminal faces which were in contact, a polish or lustre that might easily cause those faces to be taken for fractures, in a direction perpendicular to the axis. But this appearance is an illusion we must guard against: for, if we endeavour to make any fractures at the extremities of these crystals, they will take place, as usual, upon three of the alternate solid angles; and we shall find it impossible to succeed in making any fractures perpendicular to the axis, except such as are extremely irregular, and exhibit an appearance very different from that exhibited by natural ones. It sometimes happens also, that, by means of the above connection, as well as by some causes of compression, which must necessarily have been frequent with respect to crystals inclosed in their matrix, in the manner those of felspar are inclosed in granite or porphyry, that the terminal faces have varied from their natural position, and have assumed another, which inclines more or less upon the sides of the prism. We must, however, distinguish these accidental varieties, from those crystals in which such an inclination really belongs to the mode of crystallization, and which I have already described, in speaking of the sixth modification. In this latter case, the inclination of the terminal faces is constantly the same; whereas, in the accidental case here treated of, it varies considerably.

There exists also, in this substance, and even among the same crystals, (when hexaedral prisms,) not only of imperfect

corundum but likewise of the perfect kind, of all colours, another accidental variety, which is particularly met with when their irregularity and their opacity announce a want of perfection in their crystallization. Sometimes the edges of the crystalline laminæ may be perceived upon their terminal faces; and, there being more or less distance between them, they exhibit very much the appearance of an irregularity, or a kind of disturbance, in those laminæ which seem to have been deposited upon these faces, and in a direction parallel to them. But, with a little attention, we may perceive that these laminæ, the edges of which are in the direction of three of the alternate solid angles of this extremity of the crystal, can only belong to the laminæ deposited upon the faces of the primitive rhomboid; and, we are very often able, at the same time, to discover their degree of inclination.

A third circumstance attending these crystals, and one which it is more difficult to explain, consists in the appearance of concentric hexagons, parallel to the hexagon formed by the exterior edges of the crystal. These hexagons may sometimes be observed upon the terminal faces, as is shewn in Fig. 35. Their edges have a degree of thickness very perceptible by the eye; and may besides be frequently distinguished from each other, by a difference in their transparency, and sometimes also by a greater or less intensity in their colour. There are preserved, in Mr. GREVILLE'S collection, amongst a pretty large number of crystals in which this circumstance has taken place, two crystals of imperfect corundum from the coast of Malabar, that exhibit it in a very striking manner. In the first of them, one only of these hexagons, placed at nearly an equal distance from the centre and the edges of the terminal face, is of a blue

colour, while all the rest of this face is gray, slightly tinged with red, and *chatoyant*. (Fig. 36.) In the other, the last concentric hexagon alone, or that which at the same time forms the exterior part of the crystal, is (for the thickness of about half a line) of a blackish-brown colour, dull and opaque; while the rest of the terminal face (which likewise exhibits concentric hexagons) is of a gray colour, but has a silvery hue, because this part of the stone is *chatoyant*. (Fig. 37.) The above circumstance seems to announce a deposition of laminæ upon the sides of the hexaedral prism; nevertheless, if we attempt to break these crystals according to that direction, we find that it is absolutely impossible to succeed, in such a way as to obtain a fracture that has the appearance of being made in the natural joints of the stone; whereas, on the contrary, fractures may be made with sufficient ease, in a direction corresponding to the faces of the primitive rhomboid. Notwithstanding these concentric hexagons, there may be sometimes perceived, upon the same terminal faces of the prism, traces of the edges of the laminæ already mentioned; and the crystal then exhibits the appearance represented in Fig. 38. As the real direction of the laminæ (which is shown in these crystals by their natural fractures) indicates that the rhomboid of 96° and 84° is the primitive form of this substance, it seems necessarily to exclude the other direction, of the existence of which (as we have seen) there is some appearance, and which would give the hexaedral prism, as the form of the primitive crystal.

The above appearance, however, is certainly owing to a particular cause; but it seems to me, that the laws hitherto established in crystallography, are by no means capable of furnishing one that can account for it in a satisfactory manner. The only

explanation of the circumstance which occurs to me, does not agree with the idea we have formed respecting those laws; but the circumstance itself may be perfectly explained by it. It is founded upon a supposition that the primitive rhomboid may have passed, very nearly at the time the crystallization began, to the form determined by the combination of the two modifications which produce the hexaedral prism, and that, in consequence of a law not yet acknowledged, the sides of the prism may have become, at the very moment of their formation, a new centre of attraction, for the regular deposition of a part of the crystalline molecules. This supposition, however, would require another, but which perhaps may be fairly considered as nothing more than a consequence of the former, namely, that the mutual attraction of the molecules situated upon these secondary faces, is more strong than that which exists in the same way between those upon the primitive ones. This stronger degree of attraction between the molecules on one of the faces of a crystal than between those of the other, is already admitted; so that it may rather be considered here, as giving rise to an additional observation, than as affording matter for discussion. I am perfectly sensible of, and make no scruple to allow, every objection that may be made against this explanation, to arrive at which, I have been obliged to make a supposition not yet admitted; but the fact itself exists, and seems naturally to lead to the explanation I have given. I offer it, however, merely as a hypothesis, which still requires the support of observation; and I shall only add, that it is not the first time that the study of crystals has led me to form such an idea.

With respect to the cause which, notwithstanding the above-mentioned mode of crystallization, would still occasion the frac-

ture to have the same direction as if the increase of the crystal had been produced by a deposition on the faces of the primitive rhomboid, it may, I think, be explained by supposing that, in this case, the elements of the crystallization might already be real, though small, secondary crystals, for instance, small hexaedral prisms; and that the fracture would then be nothing more than the result of the sum of all the partial fractures of each of them.*

PHENOMENA WITH RESPECT TO LIGHT.

The prismatic crystals of corundum, as well as the pyramidal ones, when their extremities are terminated by faces which are perpendicular to their axes, very frequently have those terminal faces *chatoyant*. This property is the natural effect of the

* I had finished writing this Paper, when Mr. GREVILLE had the curiosity to cause one of the hexaedral prisms of imperfect corundum, from the coast of Malabar, the terminal faces of which exhibited the concentric hexagons above spoken of, to be cut transversely. This section shewed a very interesting fact, and one that adds some probability to what I have said respecting the cause which produces this phenomenon. One of the parts of this crystal (which crystal is sawed into three, and polished,) exhibits the appearance represented in Fig. 38, A. The whole substance of this segment is of a pale purplish-red colour; but there is, in its centre, a triangular spot, similar to that represented in the above figure, which indicates very clearly that the section was made below the summit of the primitive rhomboid, and perpendicularly to its axis. This spot is also of a purplish-red colour, but much more deep than the rest of the crystal, and therefore strikes the eye very forcibly. It is only to be perceived upon one of the terminal faces; the other terminal face does not show the smallest trace of it. There may, however, be perceived at its centre, a hexagonal plane, nearly as large as that represented surrounding the spot in Fig. 38, A; it is of a different colour from the other part of the substance of this segment, being of a dirty gray. The spot is also seen, but of a smaller size, upon the terminal face corresponding to the segment taken from the top of the preceding; but there are not any traces of it upon the other terminal face.

reflection of light, in the small intervals which remain between the small crystalline laminæ, in those parts where these laminæ are not in perfect contact; it is necessary, therefore, that the crystal, or fragment, which possesses this property, should be in the state most favourable to its developement. On this account, it must not be completely transparent; there being, in that case, too perfect a contact between the laminæ; so that the light, not meeting with any medium to reflect it, but being entirely refracted, cannot occasion any appearance of the property here spoken of. Neither must the crystal, or fragment, be quite opaque; it being necessary that the light, in order to undergo the reflection which produces this pleasing phenomenon, should at least be able to pass through the exterior laminæ of that part of the crystal against which it strikes. The above circumstances are, in fact, those which appear to take place with respect to corundum. The imperfect corundum of the Carnatic, the crystals of which are generally more or less opaque, show no trace of this property upon their terminal faces; whereas, it is frequently observed upon the terminal faces of the crystals of imperfect corundum from China, and also of that from the coast of Malabar, because those crystals generally possess a slight degree of semi-transparency. This character is still more common in the perfect corundum, whether sapphire or oriental ruby. There is not, however, the smallest appearance of it, when these stones possess the beautiful transparency belonging to them in their highest degree of perfection; whereas, on the contrary, it is frequently seen to take place in a very lively and brilliant manner, in such of the stones as have an inferior degree of transparency. It rarely happens, that the crystals of perfect corundum are prevented by opacity from exhibit-

ing the property here treated of; but, as I have already said, the terminal faces which, by their position, replace the solid angles of the summit of the primitive rhomboid, are absolutely the only ones which can in any degree possess it: no appearance of it can be seen in any other part. This is not surprising; for, as the effect here spoken of proceeds from the reflection of light, in the spaces between the crystalline laminæ, the plane which may be considered as produced by a section which would expose the edges of all these laminæ, must necessarily be the most proper to occasion it. This effect also takes place when the crystals are broken, by chance, in a direction more or less approaching to that which is parallel to the abovementioned plane, notwithstanding the fracture then exhibits a very rugged appearance. It even happens sometimes, that this fracture is such that the edges of the laminæ protrude, in the manner observed in the fibres of wood when it is broken across the grain; yet the property here treated of is not less evident; and, in this last case, it is often very distinctly seen proceeding from between the laminæ.

To the above property must also be referred, that beautiful reflection of light, in the form of a star with six rays, which is frequently given, by cutting, to oriental rubies, sapphires, &c. and which causes those stones to be then called by the name of *star-stones*. The manner of cutting which brings the perfect corundum into this state is, most commonly, on the part of the lapidary, rather the result of chance, than the consequence of any determined theory respecting the cause of the effect he means to produce. Accordingly, in the greater number of the stones which have this property, the point from whence the starry reflection proceeds, instead of being in the middle

of the stone, is observed to be situated in a part more or less near to its base; a circumstance which considerably diminishes the beauty of the star-stone. The reflection which produces this effect, arises from the same cause as that of which we have already spoken, and proceeds from the same part of the stone; consequently, when an oriental ruby, or a sapphire, which has the qualities necessary for the purpose, is intended by the lapidary to be formed into a star-stone, he ought to make his section pass below that part of the stone which he has found to correspond with the summit of the primitive rhomboid. As the kind of cutting most proper to produce this effect in the stone, is that rounded form which is called *en cabochon*, with as high an ellipsis as is possible, the lapidary ought, at the same time, to take great care that the summit of this ellipsis be situated exactly under the point which corresponds with the summit of the rhomboid; in that case, the light reflected in the interval of the laminæ upon the three edges of the primitive rhomboid, and upon the middle of its three faces, will trace upon the stone, a star, the six rays of which will include the circumference of the rounded part, or ellipsis. The same effect may also be made to take place on one of the solid angles of the base, but in a much less perfect manner.

I have met with many fragments of sapphires, as well as of oriental rubies, which naturally produced the effect here spoken of, in consequence of their having been broken, by chance, in a manner proper to occasion it; that is, they were broken, accidentally, in a direction contrary to that of the laminæ, and perpendicular to an axis passing through the two summits of the pyramid of the primitive rhomboid; after which, the fragment had been a little rounded by friction.

The imperfect corundum may likewise be cut in such a manner as to produce the starry reflection; but it is more rare than in the perfect kind, to meet with pieces which have all the qualities requisite for this purpose. There is, in Mr. GREVILLE's collection, a large piece of imperfect corundum, of a brown colour, which has been cut *en cabochon*, with the above-mentioned intention; but, the cutting not having been made in the proper direction, the starry reflection is exhibited in a very imperfect manner, as it proceeds from a point near the plane of the base of the stone. The effect produced, however, is sufficient to remove all doubts respecting the existence of the property here spoken of, in this kind of corundum.

CHARACTER AFFORDED BY ANALYSIS.

In order to complete the proofs I have already given, that all the stones which form the subject of this Paper are of one and the same nature, I shall borrow this last mentioned character from the analyses made by Mr. CHENEVIX, which will hereafter be described at length by that able chemist; and it may be observed, that few instances can be met with where the chemist and the mineralogist, after having jointly employed themselves in their different provinces, upon the same substance, have arrived at a more satisfactory and correspondent result.

According to Mr. CHENEVIX's analyses, the constituent parts of the various substances here treated of, are as follows.

IMPERFECT CORUNDUM.

	From the Carnatic.	From Malabar.	From China.	From Ava.
Silica	5,0	7,0	5,25	6,5
Alumina	91,0	86,5	86,50	87,0
Iron	1,5	4,0	6,50	4,5
Loss	2,5	2,5	1,75	2,0
	100,0	100,0	100,00	100,0.

PERFECT CORUNDUM.

	Blue, or sapphire.	Red, or oriental ruby.
Silica	5,25	7,0
Alumina	92,0	90,0
Iron	1,0	1,2
Loss	1,75	1,8
	100,00	100,0.

From what has been said it appears, that the analogy existing between the stones hitherto known by the names of corundum, sapphire, oriental ruby, oriental hyacinth, &c. is so strong and complete, as no longer to permit us to doubt that they ought all to be considered merely as varieties of the same substance, to which I have therefore given the general name of corundum.

In the learned work on mineralogy which the Abbé HAUY has just published, this celebrated naturalist says, that nearly at the same time I communicated to the Royal Society my first observations on this substance, he had himself observed the existence of corundum, among the crystals of

different substances contained in the sand of Ceylon; having, as he says, seen therein some small hexaedral prisms, of a ruby red colour, and transparent, which, from the analogy that appeared to exist between their external characters and those peculiar to corundum, might very naturally be ranged with that substance. Some particular circumstances certainly prevented him from making the same observations respecting the pyramidal crystals, of the above colour, which are also found in that sand; and he consequently thought it right, (although he appears to have had some doubts upon the subject,) to continue to separate the sapphire from corundum, giving to the former the name of *telesie:* indeed he has placed them at a considerable distance from each other, the sapphire being the third species of his second class of stones, and the corundum the fourteenth. What he seems to consider as the strongest arguments in favour of this separation, are, the laminated texture so evident in all crystals of corundum, and the direction of the laminæ being according to the inclination of the faces of a rhomboid; whereas, in the sapphire, this laminated texture seemed to him not to exist; and he adds, that the fractures of sapphire appeared to him to follow a direction perpendicular to the long axis of the crystal.

With regard to this, I shall observe, that in the foregoing descriptions of the characters peculiar to this substance, (which have been given with all the circumstantial detail necessary in a demonstration which is intended to leave no doubt upon the subject,) the observations of the Abbé HAUY appear to me to have been completely answered. It has there been stated, that one of the peculiar properties of this stone was, that it always preserved a very distinct laminated texture, in all those varieties

wherein the crystallization appeared not to have attained its highest degree of perfection, which varieties I have distinguished by the name of imperfect corundum. But it has also been stated, that in proportion as the crystallization possessed a greater degree of perfection, the texture exhibited a less laminated appearance; and that, in this case, it was less easy to obtain a fracture in the real direction of the laminæ.

Another circumstance has likewise been taken notice of, which appears to me to deserve some attention, namely, that in all the different varieties of this substance, the blue colour was generally accompanied with a greater degree of transparency, of gravity, and of hardness; and that, under these circumstances, in proportion as the adhesion of the laminæ was more complete, the laminated texture of the stone became less evident, and it was much more difficult, and sometimes scarcely possible, to obtain fractures in the direction of the laminæ. Nevertheless, among crystals and fragments of sapphire which had but a small degree of transparency, I have frequently met with some, in which the laminated texture was as evident as in the red prismatic variety of perfect corundum, or oriental ruby.

With respect to what concerns the fracture of the sapphire, if the Abbé HAUY was not deceived by an illusive appearance by no means rare in this stone, both in its perfect and imperfect state, (according to which the terminal faces seem to indicate a laminated texture perpendicular to the axis, or a fracture in that direction,) I cannot account for his thinking that he had obtained such a fracture as he describes. I have often tried to obtain fractures of that kind, but without success; never having been able to procure any, except such as were more or less irregular, and exhibited an appearance very different from that of fractures

made in a natural direction. Moreover, I have examined a great number of crystals of sapphire, many of which had one of their extremities, many others both their extremities, broken in a direction approaching more or less to that which is perpendicular to their axes, but have never seen, among these fractures, any one that had the appearance of being made in the natural direction of the laminæ; although, at the same time, I have, in many crystals, seen fractures which were perfectly even, and often of considerable extent, in the direction of the planes of a rhomboid, exactly similar (with respect to the measure of its angles) to that belonging to the primitive crystal of imperfect corundum. I have already observed that there sometimes remain, upon the terminal faces of the crystals of sapphire, small facets belonging to the above planes.

I cannot help mentioning also, in this place, a very interesting crystal of sapphire, that is in Mr. GREVILLE's collection. This sapphire, which is of a pale blue colour, is a simple hexaedral pyramid, the solid angle of whose summit measures 40°, and retains upon one of the angles of the summit, which is incomplete, a large triangular facet, belonging to one of the planes of the primitive rhomboid. This plane is striated transversely, in a manner that shews some derangement in the crystallization, perhaps from too great rapidity; and, in the upper part, a still more rapid decrease changes its degree of inclination, causing it to take one which is greater, and which belongs to the secondary obtuse rhomboid already described, in speaking of the fifth modification. These planes, together, completely terminate the crystal at this extremity, in the manner represented in Fig. 39. There may also be observed, two other planes, between which is comprehended the plane I have just described as one

of those of the primitive rhomboid: they are produced by the passing of the crystal to a less obtuse pyramidal modification.

Corundum is not the first mineral substance that has exhibited, even in its crystallized state, very striking differences, according to the circumstances that have governed its formation, and the greater or less degree of perfection that has taken place in its crystallization. Felspar is a substance to which the very same remarks may be applied. In the interior part of most kinds of granite and porphyry, it appears in the form of very rugged crystals, generally opaque; whereas, in the fissures of primitive rocks, it frequently has a beautiful transparency; and, when this happens, it rather exceeds the former kind in hardness and in gravity. This difference, which for a long time prevented the latter kind from being joined with the felspar of granites, is so striking, that most naturalists have thought it right still to continue to separate it, at least as a variety, although they allow it a place in the same genus, under the name of *adularia*.

There exists also in the same genus (felspar) a third variety, which, though it had long been known by the name of *white schorl of Dauphiny*, was not, till lately, brought into its proper place. This kind of felspar, which is still more perfect, presents, in such of its crystals as have the greatest degree of transparency, a brilliancy that is even superior to that of the most perfect adularia; this transparency is less similar to that of glass, and approaches nearer to that which is peculiar to the stones that have been hitherto distinguished by the names of gems or precious stones. Indeed, it always appeared to me to possess, in general, the two characters of hardness and gravity, in a somewhat greater degree than adularia. It rather scratches

adularia than is scratched by it. In the division which I usually make of the different kinds of felspar, I distinguish this latter, in consequence of the above-mentioned character, by the name of *brilliant felspar.*

We shall see hereafter, that there probably exists a fourth variety of felspar, without reckoning that which is known by its greasy aspect. The fracture of this greasy kind is dull, and resembles that of wax. It exists, in great quantity, in certain granite rocks, which usually abound with hornblende; of which rocks there is a great number in Scotland. In these, it is frequently of a green colour, which gives it exactly the appearance of jade. This kind of felspar may very probably be a particular kind of substance, nearly allied to one of those (very different from each other) to which French mineralogists give at present the name of *petrosilex.*

COMPACT CORUNDUM.

We have hitherto seen corundum only in a form more or less perfect or determined; it is, however, sometimes met with in a state in which there does not appear the smallest rudiments of crystallization. In this state, (to express which, mineralogists have agreed to make use of the term *compact,)* it resembles, in many respects, a coarse jasper; but its much greater degree of hardness, and its much higher specific gravity, render its true nature easily distinguishable.

In Mr. GREVILLE'S collection are many specimens of this compact corundum; they are all of a purplish red colour, not very deep, and are perfectly opaque. By means of a lens, there

may be perceived, here and there, some small particles, in which an incipient laminated texture is discernible. These particles are rendered visible by the reflection from the laminæ; they are of a beautiful rose colour, and have a slight degree of transparency. The lens also shows, at the same time, a great number of small globules, of a deep black colour, and of a very brilliant lustre: these globules do not consist of attractable oxide of iron, although that oxide is very common in the substance here treated of; but, on account of their small size, it has not yet been possible to determine their nature.

The compact corundum of a red colour gives pretty strong sparks, when struck with steel; it also gives, by collision, the same phosphorescent fiery red light as the other red varieties of corundum, both perfect and imperfect.

The mean specific gravity of compact corundum, taken from three trials, which differed very little from each other, was 3902.

MATRIX OF IMPERFECT CORUNDUM FROM THE PENINSULA OF INDIA, AND CHIEFLY FROM THE CARNATIC.

This matrix, which, as far as our present knowledge extends, appears to be peculiar to the imperfect corundum of this part of Asia, is a stone of a particular nature: it is sometimes in masses of a loose and granulated texture, with very coarse grains, and pretty much resembles a coarse sand stone; at other times, it has a closer texture, the grains being nearer each other, and less distinct, so as either to give it an appearance similar to the kind of marble known by the name of *coarse-grained saline marble*, or to that kind of prehnite which is composed of a mass of

crystals confusedly aggregated. In this matrix, the crystals of imperfect corundum are dispersed, in the same manner as those of felspar are dispersed in porphyry, or rather in certain granites which, besides the aggregated constituent parts belonging to that kind of rock, also contain crystals of felspar which are of a more or less considerable size, and of a perfectly determined form.

When this substance is of that texture in which the grains are closely connected together, it is of a pearly gray colour, sometimes slightly tinged with green, and has a degree of semi-transparency, not unlike that of calcedony. If a piece of this kind is moved about in a strong light, its surface shows a considerable number of small brilliant particles. This appearance arises from the reflection of the light, by the small laminæ that are exposed, in consequence of the fracture of the grains of which the stone consists; and this circumstance proves that it has a laminated texture.

In the last mentioned state, (the most perfect one in which I have observed this stone,) its hardness, although sufficient to scratch glass very easily, is rather inferior to that of felspar. It gives sparks when struck with steel; and, by means of strong collision, emits a phosphorescent light, of a bluish white colour. Friction does not produce any signs of electricity. When put into nitric acid, no effervescence was perceptible.

The specific gravity of this stone, as determined by four trials, which scarcely differed from each other, was 2742; but it is difficult to procure pieces of a tolerable size, which are not mixed, either with hornblende, or with particles of corundum.

It is fusible by means of the blowpipe.

This substance is more usually met with in pieces of a coarser

texture, in which the grains are often pretty large, so as to be easily distinguishable by the naked eye. When these pieces are in a perfect state, the grains have exactly the same colour, and the same degree of semi-transparency, as those of the preceding more compact kind. If examined with a lens, the laminated texture of these grains is very evident; and there seems to be, at the first view, a very distinct crystal in each of them. But, if we endeavour to determine the form of any one of these crystals, we find that it is absolutely impossible to do so; as the greatest part of the small facets we perceive, are nothing more than facets formed by compression. I thought, indeed, that I could distinguish some traces that indicated an obtuse rhomboid; but not in such a manner as to permit me to state the fact with certainty. These grains have but a weak degree of adherence to each other; in consequence of which, the stone may often be broken by a very slight effort.

It is, however, still more common to meet with this substance in a state wherein it has undergone, at the surface of each of the grains of which it is composed, an incipient decomposition, that gives them a whiter colour, thereby obscuring, and indeed often destroying, that semi-transparency which I mentioned as being a character of this substance, in its two preceding states. When this is the case, if some pieces of the stone are put into nitric acid, an effervescence soon takes place, the strength of which is in proportion to the degree of decomposition the stone has undergone; but this effervescence, in a short time, entirely ceases. It seems, from this circumstance, that the lime contained in the stone, (which, as will be hereafter seen in the account of its analysis, Mr. CHENEVIX found to amount to 15 parts in 100,) being exposed to the action of the air, by the

alteration or decomposition of the stone, had afterwards combined with a portion of carbonic acid.

To the above mentioned lime, (carried away by the rains which wash the exposed parts of the rocks composed of this substance, and deposited upon the fragments of corundum scattered at the feet of those rocks,) ought no doubt to be attributed, that calcareous incrustation which is frequently observed to cover, either partially or entirely, many fragments of imperfect corundum, found among the specimens of that substance sent to us from India.

If we let a piece of this matrix remain for a certain time in nitric acid, it is attacked by it, without being dissolved, and without changing its form; but if, after being taken out, it is pressed between the fingers, it may be crumbled by a very trifling effort, and may, by being rubbed, be reduced to a sort of paste.

SUBSTANCES WHICH ACCOMPANY THE IMPERFECT CORUNDUM, IN THE ABOVE MENTIONED MATRIX, FROM THE PENINSULA OF INDIA.

Felspar. There are sometimes found, in the matrix here treated of, pieces, more or less considerable in size, of a laminated substance, which has the same greenish gray colour, the same brilliancy, and, in short, the same appearance, in many respects, as the corundum itself. It is indeed the more easy to confound this substance with corundum, as it is frequently accompanied with crystals of the latter. I have myself been several times led into this mistake, before I had paid such particular

attention as I have since done, not only to corundum, but also to every thing relating to the substances which accompany it.

The most usual colour of this substance, as I have already said, is gray, slightly inclining to green, which is sometimes mixed with a small portion of brown. It possesses a pretty considerable degree of semi-transparency, which may be compared to that of calcedony, or more properly to that of the stone known by the name of cat's eye. Its hardness is inferior to that of quartz; but appears to be exactly the same as that of felspar. It gives sparks, when struck by steel; and, by collision, emits a yellowish phosphorescent light. Friction does not cause it to give any signs of electricity.

This stone may be divided with great facility, in the direction of two opposite and parallel faces; and the fractures thereby obtained have a brilliant lustre, exactly resembling that of the fractures of corundum. Upon these fractures may be observed very fine but very evident striæ, which indicate that the laminæ have a direction different from the above; but I have not yet been able to obtain an even fracture, in the direction of these striæ. All fractures made in any other direction than that first mentioned, are irregular and unequal; very often also they are dull, and somewhat similar to that of wax.

The mean specific gravity of this substance, taken from four trials, which differed very little from each other, is 2643.

This substance is fusible by the blowpipe, like common felspar.

The result of the analysis of this substance, made by Mr. CHENEVIX, is, in many respects, similar to that of the analysis

of adularia, made by Mr. VAUQUELIN; yet it differs very essentially from that, by the want of potash, and by the proportion of lime being more considerable.* The presence of the last-mentioned earth is sometimes rendered evident, in the parts which are slightly decomposed, by the weak and momentary effervescence that takes place in those parts, when the substance is put into nitric acid.

On the other hand, many of its external characters are such as naturally lead to its being ranged with adularia. It differs from it, however, in the facility with which the latter may be broken in two different directions; while, in the substance here treated of, fractures can never be obtained, except in one of those directions; nor have I ever been able to observe on the fractures of any other kind of felspar, those fine striæ which,

* The analyses made by Mr. VAUQUELIN, of the different kinds of felspar, naturally lead me to make some further remarks upon that substance; which, indeed, may be equally applied to many other substances. The able chemist above mentioned, found 14 parts of potash in 100 of adularia, and 13 in 100 of the green felspar of Siberia; whereas, he did not find an atom of that substance in another kind of felspar, which was in a laminated mass; nor in that decomposed felspar which is known by the name of kaolin. Potash may therefore be considered as not being one of the constituent parts of felspar, but merely as a foreign substance, accidentally interposed therein. Adularia, in that case, would be nothing but an impure kind of felspar; and would present the astonishing phenomenon of a substance constantly impure, in its most perfect state of transparency and crystallization. It is indeed difficult to conceive that the potash is merely interposed, in such very considerable proportion, in the kind of felspar called adularia; yet, if it really formed one of its constituent parts, it would necessarily produce a substance totally different from those which do not contain any of it; whereas, all the mineralogical characters of felspar and adularia, evidently demonstrate that these two substances are perfectly similar in their nature. There still remain, in my opinion, many discoveries to be made, in that part of chemistry which relates to the composition of mineral substances, before the chemist and the mineralogist shall be enabled to proceed together, with a certainty of agreement respecting the object of their inquiries.

as I have already said, are very evident on this stone. It differs also from common felspar, in not being capable of acquiring electric properties by friction; whereas common felspar may, by long continued friction, be made to acquire such properties. The semi-transparency of this stone likewise, and the nature of its lustre, are such as give it a greater analogy to gems or precious stones; and, in these respects, it is very similar to the variety which I have called shining felspar.

As this substance appeared to me to have a great analogy with another, which sometimes, in small fragments, accompanies the perfect corundum in the sand of Ceylon, (in which, however, they are more rare than corundum itself,) I desired Mr. CHENEVIX to be so good as to add to the analyses he was about to make, that of these fragments. The result of his analysis of them differs so little from that afforded by the substance above described, that it strongly confirms the analogy I had supposed to exist between them.

Having been so fortunate as to find, among the few fragments I could collect of the last mentioned substance, three crystals, in which the crystalline form is perfectly determined, I am enabled, by their means, to add the crystalline character of the substance, to those I have given in the foregoing paragraph. These crystals are rhomboidal tetraedral prisms, of about 100° and 80°, the two terminal faces of which are inclined, in a contrary direction, upon the obtuse edges of 100°, in such a manner as to make with them, an angle of 105° on one side, and one of 75° on the other; and as, (in the only three crystals it has yet been in my power to examine,) the planes of the prisms are very nearly equal to the terminal faces, their appearance is exactly that of a rhomboid. The terminal faces of the crystals

here spoken of are *chatoyant;* and, in the fragments, the planes which correspond to these faces have a similar property, when held in a proper direction. In some, these faces then appear of a pearly white colour; in others, the colour is rather yellowish: some of them reflect a pale blue colour; in many others, the colour reflected is a beautiful deep sapphire blue, that entirely occupies the whole extent of the face which possesses the property here spoken of. To this stone ought to be referred, that which is known by the name of moon-stone of Ceylon, when it is not of the kind called *cimophane,* (the *chrysoberyl* of WERNER,) which is often found also in the sand of this island, mixed with rubies, sapphires, &c.

The opinion I am naturally led to adopt, in consequence of the detail I have just given respecting this stone, is, that it most probably is a kind of felspar, and ought to be ranged with that substance, as forming an additional variety.

In some of the pieces of this stone, which are found in the same matrix with the imperfect corundum of the Carnatic, a talcy earth (which often also appears in a separate state) is interspersed throughout their substance, and causes them to have a less compact texture, and a very inferior degree of hardness. The stone, at the same time, acquires a slight greasiness to the touch, and loses the semi-transparency which is peculiar to it: it may still, however, be easily divided, in the direction already described as that in which it is naturally divisible.

Fibrolite. The substance I have distinguished by this name, which sometimes also accompanies the imperfect corundum from the Carnatic, in its matrix, has always offered itself to my observation, either of a white colour, or of a dirty gray. Its hardness appeared to me to be rather superior to that of quartz; as, after

having rubbed them together, the latter seemed to be the most worn of the two. It gives bright sparks, upon being struck with steel. Collision causes it to emit a phosphorescent light, of a deep reddish colour. It cannot, by friction, be made to give signs of electricity.

Its mean specific gravity, taken from four trials, is 3214.

This substance was tried with a blowpipe, by Mr. FLEURIAU DE BELLEVUE, a mineralogist much accustomed to such operations, and found to be absolutely infusible, even when placed, in very minute particles, upon cyanite.

The external texture of this substance is usually fibrous; the fibres being very fine, and closely connected together. When it is broken according to the direction of the fibres, its internal texture appears to be exactly the same; but, if it is broken in a direction transverse to the fibres, its texture appears to be compact. The lustre of the last kind of fracture is rather vitreous; and there is nothing in its appearance that gives reason to think it was made in the direction of the laminæ. When we wish to try the hardness of this stone, it should be done in a direction which is transverse or perpendicular to the fibres; not in a direction parallel to them.

There exist many pieces of this substance that are merely irregular aggregations, in which the fibres cross each other, in bundles, in different directions. I have only once seen it in a form which could be considered as a determined one; viz. a rhomboidal tetraedral prism, of about 80° and 100°, the terminal faces of which are imperfect. But, as this prism, although pretty regular in its form, is the only one I have yet been able to discover, the above observation requires to be repeated, before we can safely make any dependence upon it. I must

however add, that among the pieces of this substance, I have met with several, which appeared to have more or less tendency to the above-mentioned form.

The analysis of this substance, made by Mr. CHENEVIX, concurs with the whole of its external characters, in warranting us to consider it as being different from any of the mineral substances hitherto known; in consequence of which, I have thought it right to distinguish it by the name of *fibrolite*.

Thallite. The substance called thallite (the *epidote* of the Abbé HAUY) also sometimes accompanies the corundum from the Carnatic, in its matrix. This substance is found in three distinct states, hitherto unobserved, in all of which its appearance is so different from its usual one, as to have prevented me, for some time, from knowing it.

In one of the above states, this substance is inclosed in the matrix, in small detached masses, from the size of a pea to that of a hazle nut, and even larger. Its usual colour is either a brownish green or a yellowish green; and it has only a slight degree of semi-transparency, even at the edges.

Its hardness is the same as that of the other known kinds of thallite, which I have always found to be rather superior to that of quartz; and, as most of the other characters belonging to this kind of thallite are similar to those of the kinds already known, I shall, in the following description, mention only such of its characters as, on account of their being different, might lead to false ideas respecting it.

The major part of these small masses present no determined form; in some of them, however, a perfectly regular crystallization may be observed. In this latter state, the greater number of crystals appear in the form of rhomboidal tetraedral prisms, of 128° 30′ and 51° 30′, in which the terminal faces are perpen-

dicular upon the sides, as in Fig. 40. (Plate IX.) This form, which was before unknown in the thallite, and which might at first view be taken for a primitive one, was very likely to lead to an erroneous idea; it may however be explained by another form, which is also met with in perfectly determined crystals. In these last, the prism is hexaedral, with two edges of 114° 30′, two others of 128° 30′, and the two last of 117°; its terminal faces are also perpendicular upon the sides of the prism, as in Fig. 41. Now this form is exactly the same as one of those already observed in the prism of the common thallite, and is produced in the following manner, viz. the primitive rhomboid, the edges of which are 114° 30′ and 65° 30′, has each of its acute edges replaced by a plane, inclined, in a contrary direction, upon one of the sides of the prism, so as to make with it an angle of 128° 30′. I have often found this hexaedral prism terminated, in the same way, by planes perpendicular to its sides, among the crystals of thallite from the Alps of Dauphiny. The preceding rhomboidal tetraedral prism, consequently, is produced by an increase of the faces which have replaced the edges of 65° 30′; which increase has been such as to cause the sides of the primitive rhomboidal prism, on which each of them incline, to disappear: this is represented by the dotted lines in Fig. 42. The direction of the laminæ, in these crystals, strongly supports the foregoing explanation. Sometimes the rhomboidal prisms become of an indeterminate form, by being flattened so as to render the edges of 128° 30′ much more obtuse; when that happens, they have no longer any regular measure.

In this first state of the thallite which accompanies the imperfect corundum from the Carnatic, the pieces, whether they are crystallized or of an indeterminate form, have their surface covered with little asperities, thereby exhibiting an appearance

which cannot be better described, than by comparing it to that preparation of fish-skin which is called shagreen. This is the natural effect of their peculiar texture; for, if one of these pieces is broken, we perceive very plainly, that it is not of a homogeneous texture, but is mixed with small particles of the substance we have already described as the matrix of corundum; which mixture is often in such proportion, that the quantity of the latter substance is equal, or nearly so, to that of the thallite itself.*

The appearance the surface of these pieces exhibits, is owing to the destruction, at the said surface, of the forementioned small particles of the matrix, which, as is well known, is very easily decomposed. There sometimes even remains, in the little cavities, which are very numerous, small particles of this matrix, generally in a state of decomposition. In this case, if the pieces are immersed in nitric acid, a slight and momentary effervescence takes place; and, if this immersion is continued for some days, the acid then acts upon those particles of the matrix which are inclosed in the interior part of the substance, as has been already mentioned in the description of this matrix;

* The regularity of the form in which these crystals are found, will certainly appear surprising, when we consider the immense quantity of heterogeneous particles which are interposed within their substance, and, consequently, between their crystalline molecules, the attraction of which for each other, it would appear, must be thereby considerably obstructed; but the same circumstance takes place in other substances, for instance, in the calcareous spar known by the name of *rhomboidal sand-stone of Fontainbleau*. The Abbé HAUY, in the article *axinite*, (the *thumerstein* of WERNER,) makes the same observation, and gives a very ingenious explanation of the circumstance. This calls to our mind the remark of the celebrated DOLOMIEU, viz. that it appears, in some cases, that a foreign substance, when interposed in a crystal, instead of obstructing its crystallization, tends rather to give it a greater degree of regularity.

in consequence of which, the pieces, when taken out of the acid, may be easily crumbled by the slightest pressure of the fingers; and nothing remains in its former state, except the small particles of the thallite.

There exist some pieces, in which the particles of the matrix are infinitely more numerous than those of the thallite itself; the latter then only appears in the form of small greenish or yellowish points, disseminated in greater or less proportion, and in detached spots.

In the second of the states in which this substance is found in the matrix of corundum, it appears in the form of pretty thick prisms; these prisms have deep grooves or channels, which, as is often observed in the crystals of tourmalin, render their shape absolutely deformed. The substance, in this second state, is more pure; no particles of the matrix, which were said to be mixed with it in its first described state, are to be seen. The semi-transparency is more general, and in a greater degree. The green or yellowish colour is also more deep; and sometimes a slight tinge of red is mixed with those colours. Some parts of the pieces are less grooved than others; and those parts indicate the forementioned rhomboidal prismatic form of 128° 30′ and 51° 30′; but it is very difficult to obtain an even fracture of this stone.

In the third state, this substance is so very similar to the purest imperfect corundum, that at first I supposed it to be of the same nature; and it was not until I had examined it more particularly, that its specific gravity and its hardness, so different from those of corundum, led me to think it could not possibly belong to that substance, and that it ought, from those characters, to be ranged with the thallite. The analysis of

it, made by Mr. CHENEVIX, has proved the truth of my observations.

Its semi-transparency, in this state, is more considerable, and approaches very nearly to complete transparency. Its colour is generally a beautiful topaz yellow, which sometimes inclines slightly to green. I have hitherto met with it only in pieces of an indeterminate and irregular form, the size of which, though more or less considerable, never exceeded that of a small nut. Its fracture is generally irregular, and often partially conchoid. In some pieces, however, may be perceived small particles which seem to have a laminated texture, the direction of the laminæ being such as to announce the primitive crystal of the thallite; but I have never been able to bring this substance to the shape of that crystal, by any artificial division or fracture of it.

Hornblende. This substance is that which is most constantly, and most abundantly, contained in the matrix now treated of. There are indeed some pieces of the matrix, wherein the proportion of hornblende is as great as in some granite rocks of which it constitutes the principal component part; and those pieces have an appearance very similar to that of such rocks. It is generally of a deep black colour, and opaque; but I have sometimes seen it in the form of small elongated crystals, of a fine green colour, and transparent. Its texture is very evidently laminated; and it is seldom that any determinate form can be perceived in it; sometimes, however, the rhomboidal tetraedral form of its prism may be distinguished.

Quartz. In this matrix is also found quartz, in small detached fragments, of an indeterminate shape. This substance, however, is by no means common; on the contrary, of the various

substances that are met with in this matrix, quartz is one of the most rare. It is generally of a dull white colour, and has but a small degree of transparency.

Mica and Talc. These two substances are not very common in this matrix, yet they are more so than quartz. The mica has a silvery hue, sometimes slightly inclining to green; and, in the pieces of the matrix in which it is found, it generally appears in small detached spangles.

The talc is generally of a pale green colour; and, in those parts of the matrix where it is met with, it is in pieces nearer each other than was the case with respect to the spangles of mica. Sometimes it forms small masses, little or not at all mixed with any other substance. At other times, it is found in that very divided or earthy state (seldom without some heterogeneous mixture) which has been hitherto distinguished, after Mr. WERNER, by the name of *chlorite*.

There are also, but more rarely, met with in this matrix, pieces of real steatite, of a white or a greenish colour.

According to a letter written from Tritchinopoly, the 10th of November, 1792, to Sir CHARLES OAKLEY, then governor of Madras, and communicated by him to Mr. GREVILLE, it appears that the imperfect corundum of the Carnatic, as well as the matrix in which it is contained, forms, in the place from whence it is procured, distinct strata; and that these strata are accompanied by a substance which is in considerable abundance, and which cannot be better distinguished than by the name of talcy mica. This substance is easily separated from the matrix of corundum; and it is usual to separate it, on the spot, before the pieces containing the corundum are sent away for the purposes of commerce. Some of it was sent to Mr. GREVILLE

by Sir CHARLES OAKLEY himself. The colour of this is a blackish brown; and its exterior appearance is nearly similar to that of mica; but the lustre of its surface is somewhat less bright. Its texture is very distinctly laminated; the laminæ, which are very thin, being chiefly evident at the edges; they adhere, however, more strongly to each other than those of mica. These laminæ may be bent, without breaking; but they do not show the smallest signs of elasticity. This substance possesses but a small degree of transparency, and that only when it is brought into the state of very thin laminæ; its colour then appears a brownish yellow, not much unlike that of resin. It is much more greasy to the touch than mica; it is also less hard, so that it may be easily scratched with the nail; and, if we scratch it with the point of a penknife, we are not sensible of that kind of slight shivering which takes place when mica is so treated. Mr. GREVILLE, in the Paper upon corundum which he presented to the Royal Society, in June, 1798, was perfectly aware of the difference between this substance and that properly called mica. In the collection he received of the former, are many crystals, several of which are nearly an inch in length, and two or three lines in thickness. Some of these are in the form of a rhomboidal prism, of 60° and 120°; others have the form of a regular hexaedral prism. Upon the whole, the characters of this substance may be considered as partaking both of those belonging to mica and those belonging to talc.

Its mean specific gravity, taken from three trials, which differed very little from each other, is 2709.

Garnets. In the matrix here spoken of, and also in the corundum itself, garnets are sometimes met with; they are of a deep

red colour, and of a roundish form. There was lately sent to Mr. GREVILLE, a parcel of imperfect corundum, found among the sands of the river Kirtna, in the district of Ellore,* in the northern part of the government of Madras. This corundum, some of the crystals of which were the best defined of any I had yet seen, was mixed with pretty large angular fragments of garnets, of a very deep blood-red colour, and of the most beautiful transparency.

Zircon. The same parcel of imperfect corundum, of which I have just spoken, from the district of Ellore, was also mixed with crystals of zircon, the jargon of the lapidaries. These crystals, which were in perfect condition, deserve to be mentioned, not only on account of their size, but also on account of the great number of varieties and rare forms they exhibit. Such, for instance, is the primitive very obtuse octaedron, which is in large crystals, with sides of more than six lines in length. I had observed this form, for the first time, fifteen years ago, in some crystals found in the sands of a rivulet, called Riou Pezzouliou, which runs between the volcanic rocks at Expailly, near Puy in Velay; but these crystals were very small. The celebrated ROME' DE LISLE, who published my account of these crystals, in his excellent work on the external characters of minerals, mentions the opinion I then entertained, and had communicated to him, that the jargon and the hyacinth were only two differently-coloured varieties of the same substance, and were both derived from the same primitive form.

The most usual colour of these crystals of zircon, is a brown, which sometimes inclines to yellow: they often, however, have that fine yellowish red colour, which causes this stone to be

* This district is contiguous to that in which the diamond mines are situated.

distinguished by the name of hyacinth. Their size, and the perfection of their crystallization, enabled me to ascertain, that the angle formed by the meeting of the planes of the octaedron at the base, measures 85°; and that formed by their meeting at the summit, 95°; as is stated in the work I have just mentioned. The Abbé HAUY, in his excellent work on Mineralogy, fixes the first of these measures at 82° 50′, and the other at 97° 10′. I imagine he must have been deceived, either by the crystals having been of too small a size, or by their not having been of a perfectly regular form.

Amongst the pieces of the stone which serves as a matrix for the imperfect corundum, are found some, in which may be perceived a great number of very brilliant small points, of a yellowish red or orange colour. When viewed with a lens, these points appear to be minute crystals, perfectly transparent; but it is impossible to ascertain their form. On some of them may be perceived small facets; others have the appearance of prisms: they are of very considerable hardness. I am unable to form a decided opinion respecting the true nature of these microscopic crystals: but, all things considered, I am inclined to think it probable that they belong to the zircon.

Although these crystals, in the state I have just described, are extremely small, that state is by no means the smallest in which they are found in this substance; they also exist in it, so very minute in size, that our eyes, even when assisted with instruments, are scarcely able to distinguish them. In this state, they become a real colouring matter, for those parts of the matrix in which they are contained; which parts thereby acquire a fine orange colour, more or less deep. By attentively examining these parts with a lens of sufficient power, we may perceive

the crystals approaching nearer to each other, and diminishing in size, so as at last to become invisible: very often, they shew themselves only in the form of small filaments, scarcely perceptible.

The above is not the only substance which presents the phenomena just described, even in the stones here treated of; the thallite sometimes has the same appearances; and, in that case, it gives to the matrix a green colour, similar to its own. When this happens, we may sometimes, by means of a lens, perceive small microscopic crystals of thallite; very often, however, they are too small to be distinguished.

It appears therefore that coloured stony substances, by interposing themselves, in particles too small to be seen, in stones, may sometimes produce the same effects (and probably in the same manner) as are produced by the various metallic oxides.

Very attractable black Oxide of Iron. This ore of iron (which is the *fer oxidulé* of the Abbé HAUY, and the *magnetic iron ore* of the Germans,) is also found sometimes in the matrix of imperfect corundum from the peninsula of India; but, as we shall hereafter see, it is by no means so general, nor so abundant, in that matrix, as it is in the matrix of imperfect corundum from China. In the former, it appears in small grains of an indeterminate shape, which are sometimes interposed between the particles of hornblende, in such a way as might easily lead us to suppose, that the latter substance has the property of being acted upon by the magnet. In those parts of the matrix which contain this oxide of iron, are found hexaedral prisms of corundum, the surface of which is entirely covered by a layer of the oxide, about a quarter of an inch in thickness, and absolutely moulded upon them.

MATRIX OF IMPERFECT CORUNDUM FROM CHINA, AND SUBSTANCES WITH WHICH IT IS ACCOMPANIED.

This matrix is totally different from that of the imperfect corundum of the Carnatic, being a granite rock, composed of an aggregated mixture of felspar, fibrolite, mica, and very attractable black oxide of iron. I have not yet seen in it any particles of that particular substance, already described, which composes the principal part of the matrix of imperfect corundum from the Carnatic.

The four substances above-mentioned, are unequally distributed throughout the mass; some pieces being composed almost entirely of one of them; while, in other pieces, those substances are mixed together in various proportions, and sometimes in nearly equal ones. The crystals of corundum are disseminated in the mass, in the same manner as those of the Carnatic are in their matrix; but, as the particles of the matrix now treated of have a much stronger adherence to each other, and also to the crystals of corundum, it is difficult to detach the said crystals from the matrix, without breaking them.

The felspar has, in this matrix, the same appearance it usually has in granites. Its colour is generally reddish; very often, however, it is of a grayish white colour. I have never observed it to have any determined crystalline form; but, when it is in masses of a certain size, their texture is evidently laminated.

The mica has a silvery appearance, sometimes inclining a little to a yellowish colour, at other times to a greenish one. Its laminæ are frequently united together, so as to form prisms, which are pretty thick, but most commonly of an irregular

shape; sometimes, however, the appearance of a regular form may be observed in them.

The fibrolite is in much greater proportion in this matrix, than in that of the imperfect corundum from the Carnatic; and it is more generally dispersed throughout its substance; its fibres, however, are shorter, and form small detached diverging pencils, which unite together, crossing and penetrating each other in all directions, so as to present masses of a more considerable size. In this manner, it often entirely surrounds the crystals of corundum, and it is then impossible to disengage them from it. Its most usual colour is a whitish gray, but it is also frequently of a dull white. It is sometimes mixed, nearly in equal proportions, with felspar, and the attractable black oxide of iron; and thus produces a stone which, if polished, would have a very beautiful appearance. The analysis which Mr. CHENEVIX has made of this substance, concurs with all its other characters to demonstrate, that it is decidedly of the same nature as the fibrolite of which I have already spoken, as being found in the matrix of imperfect corundum from the Carnatic.

The very attractable black oxide of iron is, of the various substances found in the matrix of imperfect corundum from China, that which is most constantly, and most universally, mixed with it. In the smallest piece of this matrix that can be broken off, some particles of the oxide may generally be perceived; even the crystals of the corundum itself are hardly ever free from it, it being observable, not only upon their exterior surface, but also within their substance. This oxide of iron is usually disseminated, in this matrix, in small masses

of an indeterminate shape, which very often are nearly contiguous to each other. It is very rare to find among them any crystals perfectly formed; yet I have sometimes observed octaedrons, dodecaedrons, and segments of the first of these two forms, or octaedrons, which had in each pyramid, and exactly opposite, one of the faces much larger than the three others. This last form, appeared to me to be the most common one.

This oxide sometimes exists also in masses of a much larger size; but they are almost always of an irregular shape. I have often observed pieces as large as a hazel nut; and sometimes, though much less frequently, of a still more considerable size.

The mean specific gravity of this oxide of iron, taken from four trials, was 5073. This is rather superior to what has been considered as the specific gravity of this ore of iron, it having been always estimated at less than 5000. I know nothing to which I can attribute this difference, except to the peculiar texture of the oxide here described; which, as far as I have been able to observe, has always appeared to me to be much more compact than is usual in this species of iron ore. In other respects, it has, when perfectly pure, all the other characters belonging to this species.

There are some pieces of the matrix now treated of, in which the small masses of the above oxide, by being mixed with fibrolite and mica, exhibit an appearance that might cause them to be considered as pieces of a true granite; in others, it is mixed, in different proportions, with the substance of the corundum itself, in such a manner, that it is impossible, by the eye, to distinguish this mixture from the pure metallic oxide. Mr. CHENEVIX analyzed one of these pieces; and found that

it contained nearly equal quantities of corundum and of oxide of iron.

If, to what has been already said, I add, that there are sometimes found in this matrix, small pieces of green pulverulent talc, (chlorite,) and small masses of thallite, in thin elongated crystals, of a beautiful yellowish green colour, in the form of diverging rays, I shall have mentioned all the substances I have been able to observe, in the matrix of imperfect corundum from China.

Of the matrix of imperfect corundum from the kingdom of Ava, a small quantity only was sent; but that quantity was sufficient to demonstrate, that its nature is exactly the same as that of the matrix of imperfect corundum from China.

MATRIX OF PERFECT CORUNDUM FROM THE ISLAND OF CEYLON, AND SUBSTANCES WITH WHICH IT IS ACCOMPANIED.

I cannot help regretting, that it is not in my power to give much information respecting the matrix of perfect corundum from Ceylon. The precious stones comprised under that denomination, which are selected from the sands washed down by the rivers of the island, and sold under the name of *sand of Ceylon*, have never been brought to Europe in any kind of matrix, nor has any account of their matrix ever been transmitted to us. Perhaps, indeed, no more information on this head could be procured on the spot, than was obtained by those naturalists who sought for the origin of the sapphires, &c. found in the sands of the small rivulet at Expailly, already spoken of. I may also observe, that the great care taken to free the sand of Ceylon from every substance, except such as, on account of their

hardness and their lustre, are considered as of value in commerce, deprives us of all chance of obtaining that knowledge respecting the matrix here treated of, which might otherwise be acquired, from an attentive examination of the various substances which it is natural to suppose are brought down, with the sand, by the streams. We shall, however, presently see, that one of those fortunate events by which nature sometimes rewards the labours of those who devote themselves to the study of her works, has presented us with some very interesting facts on this subject.

In order to render as complete as possible, every information which is connected with the investigation of corundum in general, and particularly to make known every thing I have been able to learn respecting this stone in its highest degree of perfection, I think it right to make some remarks on the various substances with which it is accompanied, in the sand sent to us from Ceylon; although I cannot undertake to assert positively, that these substances really accompany it, when in its matrix.

Spinelle. The first of these substances, and one which composes more than nine parts in ten of the whole mass of the sand, is the spinelle ruby, now generally known by the name of spinelle. Notwithstanding the great number of crystals of this substance which are found in the sand, it is very uncommon to meet with one of a tolerable size, that is both transparent and of a perfect form: indeed most of them are merely fragments. The selection that has already been made in India, where these stones receive their first polish, in order to be distributed for sale, is no doubt the chief reason of the above circumstance:

we cannot therefore hope to find in the sand, any crystals of consequence, except such as have by accident escaped this first search; some of these, however, I have had the good fortune to meet with.

Among the beautiful series of crystals of this substance which I have been so happy as to procure, and to place in the several collections with the care of which I am entrusted by the friendship of their proprietors, there are four, in Mr. GREVILLE'S collection, that I think it right here to take notice of. The forms of these crystals appear to me to be hitherto absolutely unknown; for the Abbé HAUY, who may be justly considered as the most learned of those who devote themselves to the study of crystallography, does not even mention them, in the treatise on mineralogy he has just published.

One of these forms, is a complete tetraedron, as in Fig. 43. It is produced by the enlargement of four of the faces of the octaedron, at the expence of the other four, which it has entirely caused to disappear. There are, in the same collection, many other crystals which are passing into this form, and are more or less advanced towards it. One of them, in which there still remain some traces of the octaedron, which had entirely disappeared in the preceding, deserves also to be mentioned. This variety, which is more common than the preceding, is represented in Fig. 44.

The second of the above forms, is a very acute rhomboid, the rhombic planes of which have 120° for the measure of their obtuse angles, and 60° for the measure of their acute ones. Fig. 45. This crystal is produced by the enlargement of six of the faces of the octaedron, at the expence of two opposite faces,

one in each pyramid; which last faces have entirely disappeared. There are also several crystals in a progressive state, and more or less advanced, from the octaedron to this form. (Fig. 46.)

The third form, is a complete dodecaedron, with rhombic planes. Fig. 47. It is produced by the enlargement of the planes which have replaced the twelve edges of the octaedron; a modification to which the Abbé HAUY has given the name of *emarginée.* This enlargement is such as to have caused the entire disappearance of the eight primitive planes of the octaedron. There are also, in Mr. GREVILLE'S collection, crystals more or less advanced towards this form, some of which no longer show any traces of the planes of the octaedron, except by extremely small equilateral triangular planes, as in Fig. 48. In these crystals, it is very common to find the decrease of the laminæ evidently indicated by striæ.

The fourth form, is a rectangular tetraedral prism, terminated by two pyramids, also tetraedral, which are situated upon the sides of the prism, and have equilateral triangular planes. This crystal is produced merely by the edges of the base of the octaedron being replaced; which replacement separates the two pyramids, by a prism more or less elongated. There are some crystals in which this prism is pretty long, as in Fig. 49; others in which it is, on the contrary, very short, as in Fig. 50.

Although the Abbé HAUY has described the cuneiform octaedron, I think it right to add to his description, that, in this variety, the separation of the two opposite faces in each of the pyramids, becomes sometimes so considerable, that the crystal thereby changes its appearance, and acquires that of a rhomboidal tetraedral prism, of 109° 30′, and 70° 30′. This prism is terminated by two diedral summits, with isosceles triangular

planes, the apices of which are situated upon those edges of the prism which measure 70° 30′, making with them an angle of 125° 15′, and meeting, by their bases, at the top of the crystal, in an angle of 109° 30′, as in Fig. 51.*

I also think it right to add, to what the Abbé HAUY has said respecting the colours of this substance, that it is sometimes perfectly colourless, sometimes of a yellow colour, and sometimes of a bluish one.

We were as completely ignorant of the nature of the stone which serves as a matrix to the spinelle, as we were respecting that of the matrix of the perfect corundum of Ceylon, when a number of specimens were sent from India to Sir JOHN ST. AUBYN, by Mr. WHITE, amongst which were two pieces of the highest value, inasmuch as they served to show us, for the first time, the substance now treated of, inclosed in its matrix. I flatter myself a description of these two pieces will be thought worthy the attention of the Royal Society, particularly as they also contain a species of iron ore hitherto unknown.

One of these pieces is a calcareous spar, of a granulated texture; the grains are very large, and are intermixed with each other, so as to adhere very strongly together, but their

* The dodecaedron, and the octaedron passing very rapidly to the tetraedron, had already been mentioned by Mr. ESLINGER, (*Journal de Physique*, Vol. LII. p. 225,) as making part of the collection of crystals of this substance in Mr. WERNER'S possession: the other varieties had not yet been described. According to some of the external characters by which Mr. ESLINGER describes the spinelle, I am inclined to think, that he includes some Ceylanites in that description, and also some oriental rubies. Such, for instance, I suspect to be, that which he says has a starry reflection; also the hexagonal prism with the alternate angles of the base replaced; and the cube, (without doubt, slightly rhomboidal,) which has a small plane upon two of its solid angles diagonally opposite to each other: a form that is very rarely met with, even in the oriental ruby.

fracture shows that they are very evidently laminated. In the substance of this spar are contained a great number of small prismatic crystals of mica, of a beautiful yellow colour, like that of the topaz; they have also the lustre, and the transparency, of that precious stone, for which they might the more easily be mistaken, as several of them, which show the sides of their prisms on the exterior part of the stone, appear to have their surface slightly rounded.* Very thin laminæ may without difficulty be detached from the terminal faces of the crystals; these laminæ are perfectly elastic.

There are also, in this calcareous spar, small pieces of a metallic substance, which deserves to be particularly described.

The colour of this substance is gray, slightly inclining to red, so as very much to resemble that of arsenical cobalt, or of nickel. The substance is very brittle; the slightest blow breaks it; and it may, by a moderate degree of pressure, be reduced into a black powder. Its fracture is conchoid, with a very fine and compact grain; and it has a very brilliant lustre. The magnet

* All the authors who have treated of mica, say that it is transparent only when in very thin laminæ. This is a mistake. When the crystals of this substance are in as perfect a state as they possibly can be, that is to say, when their crystalline laminæ are in complete contact with each other throughout the whole extent of their surface, (a circumstance very uncommon, but which is known by the sides of their prisms being perfectly smooth,) they are usually transparent. I have seen crystals of mica, of a pretty considerable thickness, which were perfectly transparent, in whatever direction they were viewed; although sometimes such crystals, when their terminal faces have a very shining silvery lustre, (which shows that they reflect all the light that falls upon them,) have not the smallest transparency, when viewed in a direction perpendicular to their axis; many of them, however, appear transparent, when viewed through the edges of the laminæ, that is to say, in a direction parallel to that of their axis. The above is not the only mistake that has been made with respect to this substance; a correct description of which, I hope, some time hence, to be able to lay before the Royal Society.

acts upon it, very nearly as strongly as it does upon iron in a perfectly metallic state. When this substance is immersed in nitric acid, no effervescence takes place. By means of a file, or merely by the blade of a knife, a black powder may easily be obtained from it, without in the least diminishing the lustre of the part from which it is taken. If a magnet be brought near this powder, it is instantly attracted by it. Those parts of this substance which appear to have been exposed for any length of time to the contact of the air, are become of a black colour.

I know no other metallic ore whose exterior characters are analogous to those I have just described; and I very much regret that the scarcity and the consequent value of this specimen, as well as of that about to be described, prevent their being made use of for the purpose of an analysis, the result of which it would be so desirable to be acquainted with. If, without such analysis, I might be permitted to form an opinion respecting this substance, I should be much inclined to consider it as a martial pyrites, or sulphuret of iron; but in which the iron, in a metallic state, is combined with a much smaller quantity of sulphur than in common pyrites; some small traces of the latter, however, may be perceived in this specimen, by the side of the metallic substance above described.*

In this same calcareous spar may also be observed, small crystals of a greenish colour, which have hexaedral prisms; they are of very inconsiderable hardness. I believe they belong to that particular species of phosphate of lime, which the Germans have distinguished by the name of *spargelstein*.

* Since the above was written, I gave a few grains of this substance to Mr. CHENEVIX; who, from that small quantity, was able to determine that it contained nothing but iron and sulphur.

But, what renders the specimen I am now describing, in the highest degree interesting, is, that there are some perfectly well formed octaedral crystals of spinelle, of a pale purplish red colour, inclosed therein. Here then we have a fair and unquestionable instance of the spinelle within its matrix: we shall however see presently, that the nature of this matrix is not constantly the same.

The second of the two pieces I have mentioned above, as being the matrix of the spinelle, is a mass of adularia, of a grayish white colour, about six inches in length, and of a proportionate thickness. This adularia is tolerably pure, in one half of the piece; but, in the other half, it is mixed with particles (much more considerable in size, and in much greater proportion than in the preceding piece,) of the very brittle and very attractable metallic substance already described. There may also be observed in it, some small pieces of a substance of a brownish green colour, but which becomes grayish when scraped; this substance, which is by no means hard, appears to me to be of the nature of steatite. If this specimen is moved about in a very strong light, there may be perceived in it, here and there, small particles, which have a silvery appearance, and which are rendered very evident, by their laminæ being in a direction contrary to those of the adularia which is near them. I consider these small pieces as belonging to the kind of felspar I have already described, and mentioned as being found in the sand of Ceylon which contained the perfect corundum and the spinelle, and as frequently reflecting a beautiful deep sapphire blue colour. This specimen contains fewer crystals of spinelle than the preceding one; some, however, may be perceived in it. It seems also to contain particles of calcareous earth, which

appear to be situated between the laminæ of felspar; at least, if a piece of it be broken off, and put into nitric acid, a slight effervescence is produced, which however is but momentary. These particles are most numerous, at those parts where the felspar and the metallic substance already described come into contact with each other.

I have placed a specimen of each of these stones in Mr. GREVILLE'S collection.

Notwithstanding there is a considerable difference in the nature of the matter which may be considered as the basis of these two pieces, yet the particular nature of the substances contained in them, which are perfectly similar to each other, seems to render it highly probable that the place of their origin was the same. But it also appears probable, from every circumstance respecting these stones, that they must have come, not from a mass of rock of the same nature as themselves, but from some veins, to the destruction of which may also very likely be owing the great quantity of spinelles contained in the sands of certain rivers of Ceylon. Would it be hazarding too much, to suppose that the crystals of perfect corundum which are found in this sand have also the same origin; and that (being much more rarely met with, and in much less quantity,) they have only a partial existence, or one that is confined to certain parts of the veins already spoken of. The small portions of felspar, and also of calcareous spar, which are sometimes, although very rarely, found in this sand, (perhaps because the sand has been already freed from such substances,) tends to support the supposition I have just made, namely, that these two substances are a mong those which compose the real matrix of the stones here treated of.

Tourmalin. This substance is also frequently found in the sand of Ceylon: indeed it is in this sand that the most perfect crystals of tourmalin, the most transparent, and the most various in colour, are generally found. It is certainly to be lamented, that these crystals are seldom of any considerable size; but that defect is compensated by the perfection and regularity of their form. Among these, I have found two in particular, of which, as they have not hitherto been noticed, I think it right to give a description.

The first of these forms, is the very obtuse rhomboid which is represented in Fig. 52, and is the primitive crystal of this substance. The Abbé HAUY, who also thinks that this rhomboid is really the primitive form of this substance, appears not yet to have met with it; for he has not placed it at the head of the description of tourmalin given in his mineralogy, as he has done with respect to the other substances of which he has observed the primitive form. It is indeed very scarce. I have, however, met with it several times; and have placed a very fine specimen of it in Sir JOHN ST. AUBYN'S collection. This crystal, which is about four lines in diameter, and nearly two lines in thickness, is of a brown colour with a tinge of orange; it is also pretty transparent, even in the direction of its axis. Its form is perfectly well defined; and the two pyramids, of which its rhomboid may be considered to be formed, are exactly similar to each other; neither of them having any supernumerary facets.

I think it right here to observe, that there appears to me to have been an error committed, with regard to the measures that have been given as those belonging to the primitive crystal of the tourmalin. The Abbé HAUY fixes the measure of the solid

angle of the summit of the pyramid at 136° 54′ 41″. ROMÉ DE LISLE's measure is nearly the same, namely, 137°. I have measured this angle with more than usual care, (on account of my not agreeing with these two celebrated naturalists,) having taken the precaution of using several different goniometers, and I have constantly found it to be 139°; which would make the angles of the rhombic planes 114° 12′, and 65° 48′, instead of 113° 34′ 41″, and 66° 25′ 19″, as stated by the Abbé HAUY.

The second of the forms abovementioned is a prism, either hexaedral, enneaedral, or dodecaedral, of which the terminal faces are perpendicular to the axis. This variety is produced in the following manner, viz. the plane that has replaced the solid angle of the summit of the pyramid, (which plane is represented by the Abbé HAUY in Figs. 119 and 120, Plate LII. of his Mineralogy,) has acquired an increase of sufficient extent to cause the planes of the pyramid entirely to disappear.

I think it right to add here, a variety of this substance, which also comes from Ceylon, and has not yet been described, namely, a prism which has become of a triedral form, with equilateral bases, by the enlargement of the planes that have replaced the three alternate edges; the formation of which planes is known to change the hexaedral prism into an enneaedral one; and the enlargement is such as to cause the six others entirely to disappear. The tourmalins of Ceylon are not the only ones in which I have observed this triedral prism: I have also met with it among the tourmalins of Saxony, and among those of Bohemia.

Lastly, I shall add, as forms not yet described, (although they do not belong to tourmalins of Ceylon,) two complete triedral pyramids, which, if they were not separated by an intermediate prism, would produce two secondary rhomboids, the

one more acute, the other more obtuse, than the primitive rhomboid.

The first of these pyramids, is the natural produce of the increase of the planes which have replaced the acute angles of the rhombic planes of the primitive crystal: these planes are represented at the letter *o*, in Figs. 114, 115, 116, and 121, Plate LII. of the Mineralogy lately published by the Abbé HAUY. This learned mineralogist has indeed represented a considerable increase, but not a complete one, of the above-mentioned planes, in Fig. 121, which he says was communicated to him by Mr. LA METHERIE. From the appearance of this form, I think it probably belongs to the tourmalins of Regensberg, in the Upper Palatinate; for many crystals of tourmalin from that place exhibit, at one of their extremities, the pyramid represented at Fig. 121 of the work just mentioned, and the pyramid I have here described, at the other. This triedral pyramid measures 107°, at the solid angle of its summit.

The second of the pyramids, is produced by the increase of the planes which have replaced the edges of the pyramids of the primitive rhomboid: these planes are represented by the Abbé HAUY at letter *n*, in Figs. 118, 119, and 120, also of Plate LII. The triedral pyramid which these planes produce, after having caused every trace of the planes of the primitive rhomboid entirely to disappear, has, very nearly, 159° for the measure of the solid angle of its summit. I have seen this variety among the tourmalins from the Ural mountains, in which, very often, the solid angle of their summit is replaced by a plane, of greater or less extent, which is perpendicular to their axis.

Among the various colours exhibited by the tourmalins which

are found in the sand of Ceylon, there are three which deserve notice, because they have not yet been mentioned by any author; these are, a light yellow, like the colour of honey, a beautiful clear emerald green, and a red slightly inclining to purple. The green variety, which indeed might easily lead to a false idea of the stone, is, most probably, what has caused some authors to mention the true emerald as being indigenous to Ceylon, where, hitherto, no trace of that stone appears to have been met with. This error was the more likely to be committed, as it was not then known that the regular hexaedral prism, with terminal faces perpendicular to the axis, was one of the crystalline forms belonging to the tourmalin; and that tourmalins of a beautiful emerald green colour, and perfectly transparent, were sometimes met with of that form. I have placed some very pretty small crystals of this kind in Mr. GREVILLE'S collection.

The tourmalin of a purplish red colour, found in the sand of Ceylon, is exactly similar to that of Siberia, to which the names of *rubellite*, of *daourite*, and of *Siberite*, have been successively given, and which the Abbé HAUY has ultimately distinguished by the name of *apyrous tourmalin*. Its form is precisely the same as that of the tourmalin, properly so called; nor does the measure of its angles exhibit any difference; especially if that measure is taken upon crystals which are of a perfectly determined form, and which have not, upon their pyramidal planes, any aggregation that can cause a change in the form of those planes. I have placed in Mr. GREVILLE'S collection, a small group of this kind of tourmalin, from Ceylon, the colour of which is a beautiful red; among its crystals, which have triedral pyramids with rhombic planes, may be observed one that has a dodecaedral prism, with its terminal faces perpendicular to its

axis. In Sir JOHN ST. AUBYN's collection, I have placed a detached crystal, which has also a dodecaedral prism; one of the extremities of this crystal is of a green colour.*

Lastly, I have, in this same sand, met with a crystal, perfectly colourless, the prism of which is completely triedral;

* The scarcity of the red tourmalin of Siberia, which hitherto has been known only by very small specimens, for which the dealers demand an extraordinary price, seems to be what has hitherto prevented naturalists from forming a decided opinion respecting its proper place in the system of minerals. I am therefore happy in announcing, that there is in Mr. GREVILLE's collection, a specimen of this kind of tourmalin, (from India,) the size and perfection of which are truly admirable. This specimen, which is not accompanied with any kind of matrix, is nearly as large as a man's head; and is entirely composed of crystals placed by the side of each other, in a diverging form, or rather penetrating each other at one of their extremities, and separating or diverging a little at the other extremity. Every one of these crystals, most of which are as long as the height of the specimen, is nearly as thick as the little finger. Their form is a hexaedral prism, which is deeply striated, and terminated by a triedral pyramid with rhombic planes, the angles of which, measure exactly the same as those of the corresponding pyramid in the common tourmalin. All the crystals are pretty transparent; and terminate on the top of the specimen, by the forementioned pyramids, but at different heights; a circumstance that gives to the top also a triedral pyramidal form, but much less obtuse than that belonging to each crystal of which it is composed. The greatest part of this specimen is of a pale purplish red, or flesh colour; but, towards the base, this colour grows much more deep, so that, at last, it becomes absolutely black. I have observed the same division of colour, in specimens of this red tourmalin from Siberia.

The superb specimen here described was brought from the kingdom of Ava: it was given by the sovereign of that country, as a present of very great value, to Colonel SYMES, who was sent on an embassy to him, by the English government. Colonel SYMES placed it in Mr. GREVILLE's collection; and he could not possibly make a better use of it; that collection being, in my opinion, one of the finest in Europe, with respect to the beauty of the specimens and the instructive series of each substance which composes it, and certainly superior to all others, with respect to precious stones in a state of perfect crystallization.

The Abbé HAUY, in his Mineralogy, expresses a wish, that the prismatic enneaedral form, terminated by the triedral pyramid of the primitive rhomboid, (which he

and the pyramidal planes of which, in the only extremity of the crystal that remains, are situated upon the edges of the prism.

Ceylanite. The stone called Ceylanite, by Mr. LA METHERIE, who is the first author that has considered it as a particular and distinct species, (distinguished by the name of *pleonaste*, in the Mineralogy of the Abbé HAUY,) is also sometimes found in the sand of Ceylon; it is, however, in general, by no means common. Of the crystals of this substance that I have collected from this sand, many are perfectly transparent; a character which appears to have been hitherto unobserved in it. Its colours are very various. Besides black and green, which have already been mentioned by authors, I have seen it of a reddish or flesh colour, with a yellowish cast; of a fine bluish green, like the aqua marine; and of a fine sky blue, rather pale. When the Ceylanite is of the last-mentioned colour, whether it be a fragment or a flattened octaedron, it might very easily be mistaken for a sapphire. Its most usual colour is a brownish green.

As this substance has, in all its external characters, a striking resemblance to the spinelle, of which it is perhaps only a species, I think I cannot be too particular in pointing out those characters which may in some measure serve to distinguish it; I shall therefore add, that its hardness is rather inferior to that of the spinelle, the Ceylanite being scratched by the spinelle, while the latter cannot be scratched by the Ceylanite; also, that it usually exhibits, by irregular striæ, parallel to the edges of the regular

calls *isogone*,) may be met with in this substance, in order to determine its nature. He will no doubt feel satisfaction in hearing, that there exists, in the collection of Sir JOHN ST. AUBYN, a small detached crystal of this substance, of a fine red colour, which has exactly the above-mentioned form. This crystal I found in the sand of Ceylon.

octaedron, its primitive crystal, a tendency to the replacing of all those edges; an appearance which is very common in the octaedron of the diamond. I shall remark also, that the surface of its crystals has generally less lustre than is commonly observed in the crystals of spinelle.

The desire of contributing every thing in my power, to render as complete as possible our knowledge respecting this substance, which has been but lately known to mineralogists, induces me to add to the variety of forms that have been described by the Abbé HAUY, those represented in Figs. 53 and 54, although the Ceylanite to which those figures belong comes from a different place. The first is nothing more than the modification represented by the Abbé HAUY in Fig. 104, Plate L, of his work, but in which the four planes that have replaced each of the solid angles of the octaedron, are situated upon these same angles, in the primitive crystal itself, instead of being situated upon the planes that have replaced the edges. I have frequently seen these planes encroach upon each other, to such a degree as to render it very probable that there exists, in the Ceylanite, that form of crystal which consists of 24 trapezoidal facets, and which, by its derivation from the cube, the regular octaedron, and the regular dodecaedron, is already so very common in crystallography.

The second of the forms just spoken of, (Fig. 54.) is the same variety, but with a very slight replacement of the edges of the octaedron: it is the beginning of the change to the above-mentioned Fig. 104, of the Abbé HAUY. These two varieties belong to the Ceylanite which is inclosed in pieces of stone brought from Somma; and are indeed the most common

varieties found in them, except that in which the edges only are replaced.

Zircon. This substance is, next to the spinelle, that which is most frequently found in the sand of Ceylon. It is true, that it is generally in crystals of a very small size; but these crystals often possess the most beautiful transparency, and they are of many different colours. To the colours already mentioned as belonging to them, I may add, that they are sometimes of a reddish purple, and sometimes of a pale blue.

Lastly, if to the substances which have already been described, I add, that there are also some small scattered fragments, but in very inconsiderable quantity, of quartz, of felspar, of calcareous spar, of a brownish yellow mica, and of attractable oxide of iron, I shall have enumerated all the substances that are found in the sand of Ceylon, in the state in which it is sent to us. I have always been astonished at not finding in it any of the peridot, which, as is well known, also comes from Ceylon: hitherto, however, I have not perceived the smallest trace of it.

Of the various substances that have been here described, the spinelle is that which more particularly constitutes the sand of Ceylon, such as it comes into Europe; but it is natural to suppose, as I have already had occasion to observe, that the sand has been previously examined, and deprived of every substance, except those which are found by experience to be fit for the purposes of commerce. The other substances above mentioned, are not so constantly found in it, nor are they found always in any regular proportion. I have seen, for instance, some of this sand which did not contain an atom of perfect corun-

dum; other parcels which contained only a very small quantity; and others in which the proportion of that substance was pretty considerable: the same remark may be applied to every one of the other substances. It is therefore, I think, fair to conclude, from the above circumstances, that these sands come from different rivers or rivulets, or, if from one river only, from one into which other rivers discharge themselves; and that the nature of the sand varies, according to the particular circumstances which may have caused one or more of those rivers to bring down a greater, and others a less proportion, of the substances of which it consists. It may indeed also be asked, if what is called the sand of Ceylon comes exclusively from that island? To this question, I can give no decisive answer. I shall only observe, that the length of time it has gone under that denomination, without any alteration, gives some reason for thinking it has really some claim to it.

It is, at this time, a doubtful point, whether corundum is found in any part of the world, besides certain districts of the East Indies; although, as will presently be seen, I have strong reasons for thinking that it also exists in one of the mountainous provinces of France.

I have seen many specimens which were sent from Germany, under the name of corundum; some of them were nothing more than felspar of a brownish red colour; others were the stone called *schorlartiger beryl*, by WERNER, (the *pycnite* of the Abbé HAUY,) but in pieces which were rather less striated than is usually the case with respect to that stone.

It was thought, for some time, that a stone found at Tiree, on the eastern coast of Scotland, was of the nature of corundum.

But, after examining a specimen of that stone, which is in the British Museum, I found that its hardness, and its specific gravity, were both very inferior to those of corundum. In its exterior appearance, it very much resembles the felspar that accompanies the imperfect corundum from the Carnatic, and which I have already described, when speaking of the substances which accompany that kind of corundum in its matrix.

It is also said that corundum has been found in America, at Chesnut Hill, near Philadelphia. But there are, in the Philosophical Magazine, No. 45, for February last, some observations made by Mr. RICHARD PHILIPS, upon the external characters of the American stone, intended to show that it cannot possibly be corundum. Mr. PHILIPS has since told me, that the specimen upon which his observations were founded, was sent to him directly from Philadelphia, as a piece of the corundum found near that city. He also recalled to my mind, (which I had entirely forgot,) that he had shown me the specimen some time before; and that I then gave it as my opinion, that the crystal it contained, supposed to be corundum, was nothing more than an ill-defined crystal of quartz. Nevertheless, Mr. SMITH, a well-informed mineralogist, from America, has since assured me of the truth of the discovery of corundum, in the neighbourhood of Philadelphia. In that case, there must have been some mistake respecting the specimen that was sent to Mr. PHILIPS. Upon the whole, there still remains some uncertainty with regard to the existence of corundum in the neighbourhood of Philadelphia; and it is necessary, in order to remove all doubt on this head, either that some of the substance should be sent to us, or that some mineralogist in that country should give

such an accurate description of its characters as may serve to ascertain its real nature.

It remains for me to speak of the corundum I formerly found, or at least thought I found, in Forez, in the mountainous parts of that province which are near Montbrison. I find, by the Mineralogy of the Abbé HAUY, (Vol. IV. p. 362.) that the substance I had considered as corundum, is now looked upon in France to be of a different nature. That learned mineralogist, in the abovementioned work, seems inclined to consider it as a species of felspar, and gives it the name of *apyrous felspar*. He admits however, at the same time, that it scratches quartz; that its specific gravity is 3165; and that it is infusible by means of the blowpipe. All these characters seem to place it at a considerable distance from felspar.

The total loss of a very considerable collection of minerals, intended expressly for the purposes of study, (and which I regret the more from its having been entirely formed, and most of the specimens collected in their native places, by my own hands,) leaving me no objects of comparison, I can only consult, with regard to the above substance, the few notes I have been so fortunate as to preserve, assisting them with such circumstances as my memory has been able to retain.

I find in my notes,

First, That this substance was inclosed in a yellowish felspar, which formed a small vein in a granite rock; that, in some parts of the felspar, it appeared in the form of small spots, easily distinguishable by their colour, which was red with a purplish tinge; and that, in other parts, it was in masses of a rather larger size, from which I was able to extract some fragments.

Secondly, That the appearance of this substance was entirely different from that of felspar; and that, where it came in contact with the felspar, it seemed to mix itself with it in such an insensible manner, that, after having sawed and polished a piece composed partly of felspar and partly of the substance here spoken of, it was impossible, by the eye, to distinguish exactly where the felspar began, or, which is the same thing, where the other substance terminated.

Thirdly, I find also by my notes, that the pieces I had collected, varied considerably in their degree of hardness, although all of them were harder than felspar usually is; for many of these pieces would scarcely scratch felspar; whereas others could scarcely be scratched by the greatest number of gems or precious stones. The characters of the last mentioned or hardest pieces, appeared to me to be very similar to those of the imperfect corundum from China, a crystal of which ROMÉ' DE LISLE had sent me a short time before. The above observations, joined to the remarkable manner in which this substance is mixed with felspar, made me adopt the erroneous opinion mentioned by the Abbé HAUY, in his observations upon corundum, namely, that this substance might be nothing more than a more dense variety of felspar. I soon, however, entirely gave up this idea, after I had it in my power to examine more particularly the nature of corundum.

Fourthly, and lastly, I find by my notes, (and I also remember it perfectly well,) that among the pieces I was able, by patiently and carefully using the tools employed for that purpose by mineralogists, to extract from the vein above mentioned, there were some to which adhered small irregularly shaped pieces of a substance that was perfectly transparent, and had

a fine sapphire blue colour. The hardness of this substance was such as to be equalled only by that of the sapphire itself; and, in some of the pieces, instead of adhering to the outside, it was dispersed, in very small particles, within the interior part.

As I cannot, even at this time, consider this blue substance as any thing else than the blue perfect corundum known by the name of sapphire, I still retain the opinion I formerly thought it right to adopt, namely, that the substance to which it adhered, and which I found in the province of Forez, was really a kind of corundum. I still think also, that the variety I observed in the degree of hardness, and in the specific gravity, of different pieces, was owing to their being mixed, in various proportions, with felspar. If it should happen that, among the remains of a collection of which nothing is left to me but a painful remembrance, (although, as I have before said, my present situation is such as much alleviates my regret,) any of the specimens above spoken of still exist, and should fall into the hands of well informed naturalists, I hope they will let them serve as a basis for fresh observations. The description of the Abbé HAUY is alone sufficient to show, that the above substance cannot possibly be a kind of felspar. I am sorry, however, that he did not join to his description, the analysis of the substance; it certainly would have been very interesting, particularly if, as would most probably have been the case, the hardest pieces had been selected for that purpose.

The great difference sometimes observed in different specimens of the same substance, is exhibited in a very striking manner, in the emeralds which I found, at the same period, in a large vein of the fore-mentioned rock, but which was situated

in the part of the rock opposite to that wherein I discovered the blue substance already described. The Abbé HAUY, in his Mineralogy, (Vol. IV. page 361,) mentions these emeralds, but expresses some doubts respecting them. These doubts I think would be removed, if I had it in my power to send him the specimens I then collected. Among them were some crystals, which possessed a degree of hardness fully equal to that which is known to belong to the emerald: the hardness of many others was, however, very inferior; owing no doubt to the interposition of some heterogeneous substance, which I always suspected to be of a magnesian nature.

The Abbé HAUY, in order to fix his opinion respecting this substance, appears to require nothing but to see some crystals of it which possess the additional facets peculiar to the true emerald. I cannot indeed shew him such crystals; but I can supply the want of them, not only by my notes, but also by models cut in wood, which I was so fortunate as to bring away with me, as well as the whole collection of models of which they form a part. I find, among the models I made of these emeralds from Forez, all the varieties the Abbé HAUY has represented in Plate XLV. of his work, excepting only Fig. 50. of that Plate.

Fig. 1.

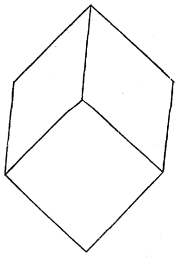


Fig. 2.

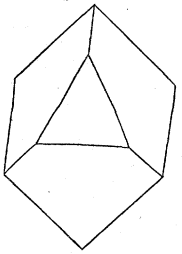


Fig. 3.

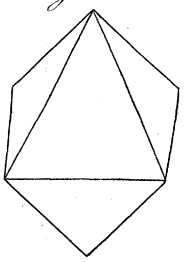


Fig. 4.

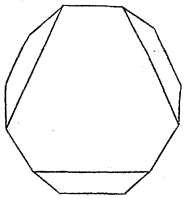


Fig. 5.

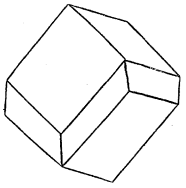


Fig. 6.

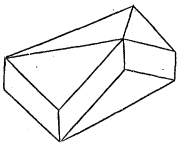


Fig. 7.

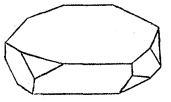


Fig. 8.

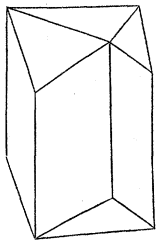


Fig. 9.

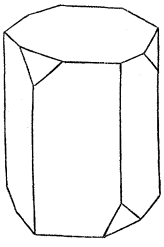


Fig. 10.

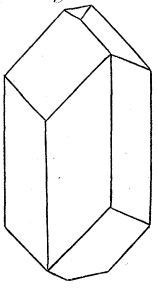


Fig. 11.

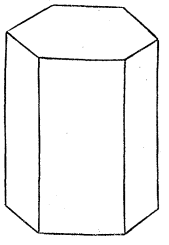


Fig. 12.

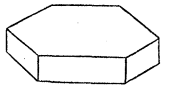
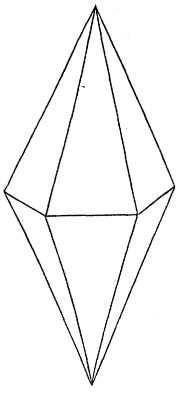


Fig. 13.



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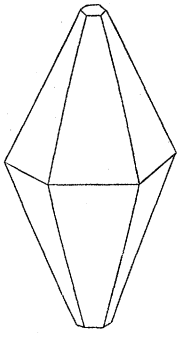

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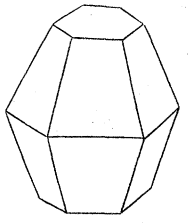

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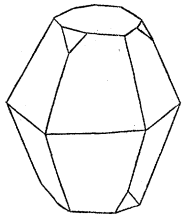

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Fig. 17.

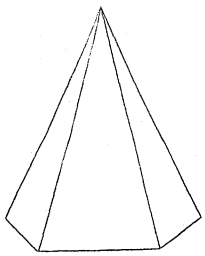


Fig. 18. A

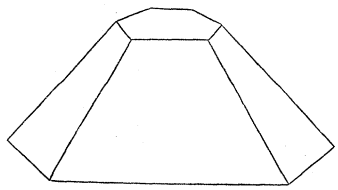


Fig. 18. B

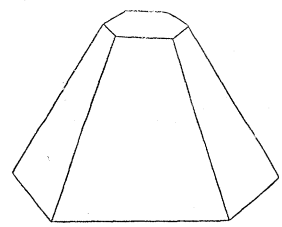
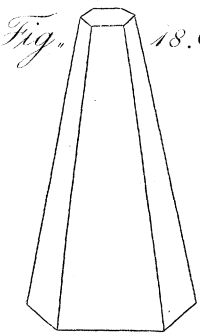


Fig. 18. C



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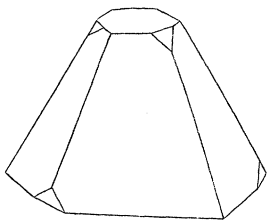

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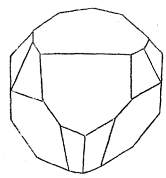

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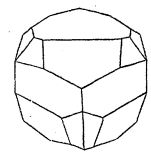

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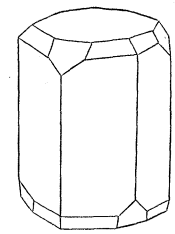

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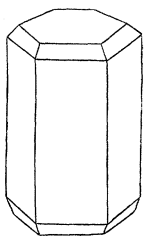

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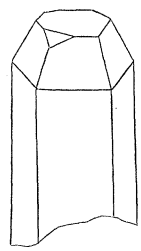

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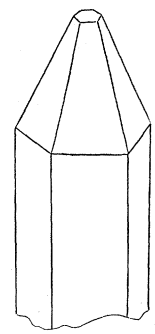

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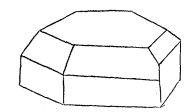

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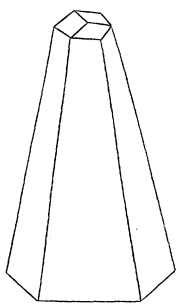

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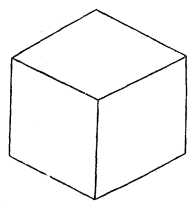

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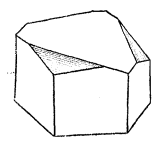

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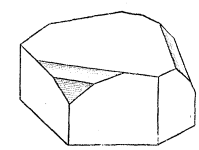

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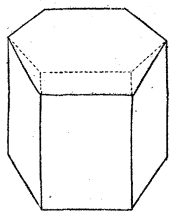
Fig. 31.



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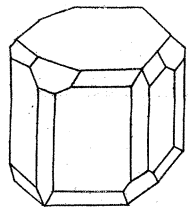

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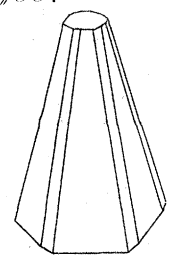


Fig. 34 A.

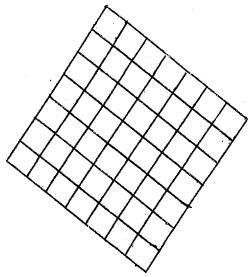
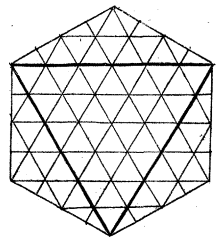


Fig. 34 B.



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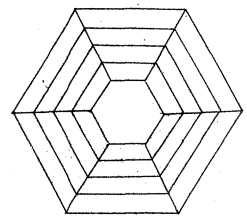

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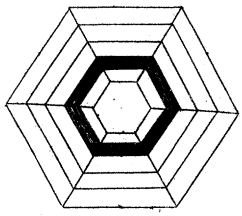

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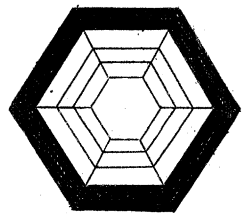

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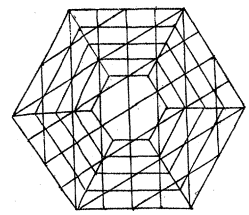


Fig. 38 A.

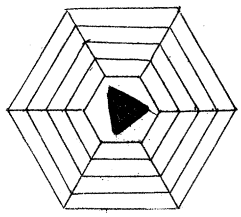


Fig. 39.

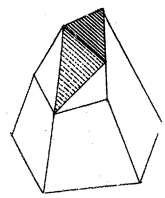
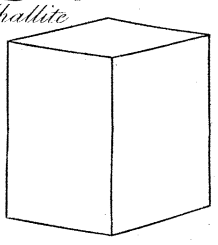


Fig. 40.

Thallite



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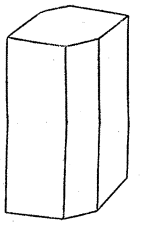

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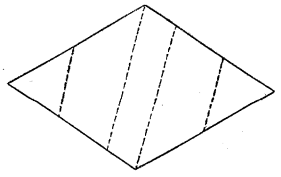
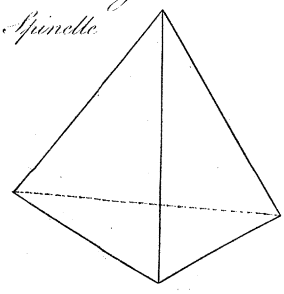


Fig. 43.

Spinelle



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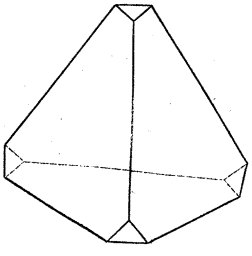

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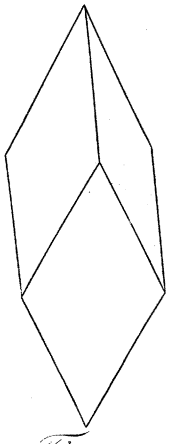

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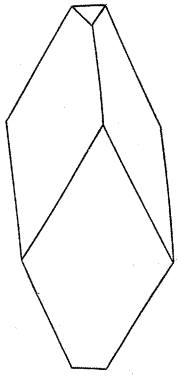

Fig. 47.

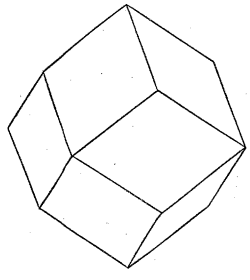

Fig. 48.

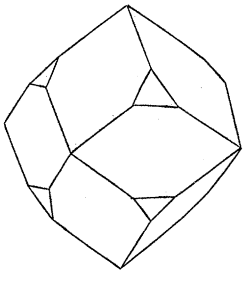

Fig. 49.

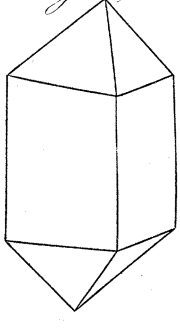

Fig. 50.

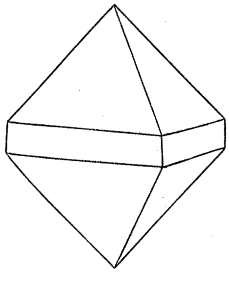

Fig. 51.

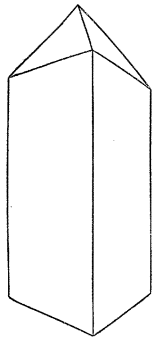

Fig. 52.

Tourmalin

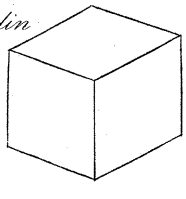

Fig. 53.

Ceylanite

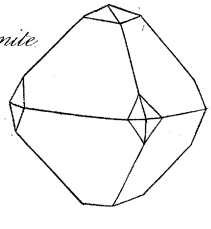

Fig. 54.